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Plastering and Fireproofing

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Prepared Under Supervision of

WILLIAM S. LOWNDES, Ph. B.

MEMBER, AMERICAN INSTITUTE OF ARCHITECTS
DIRECTOR, SCHOOLS OF ARCHITECTURE AND BUILDING CONSTRUCTION
INTERNATIONAL CORRESPONDENCE SCHOOLS

PLASTERING
HOLLOW TILE
FIREPROOFING OF BUILDINGS
AREAS, VAULTS, AND RETAINING WALLS

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PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed.

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CONTENTS

NOTE.—This volume is made up of a number of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

PLASTERING	<i>Pages</i>
Preparation of the Base	1-12
Surfaces to Be Plastered	1
Furring	2- 5
Grounds	6- 8
Corner Beads	9-12
Lath	13-31
Wooden Lath	13-16
Metal Lath	17-28
Plaster Boards and Wall Boards	29-31
Interior Plastering	32-51
Preparation for plastering; Plasterers' tools; Lime plaster; Gypsum plaster; Application of lime plaster; Application of gypsum plasters; Keene's cement; Portland cement plaster; Caen stone plaster.	
Ornamental Plastering	52-62
Materials and preparation; Application of the plaster.	
Exterior Plastering	63-90
Stucco	63-86
Kinds and advantages; Preparatory work for stucco; Materials for stucco mortar; Proportions of materials; Mixing; Applying the stucco; Stucco finishes; Color effects; Waterproofing of stucco; Magnesite stucco.	
Miscellaneous	87-90
Whitewashing; Overcoating.	

HOLLOW TILE

Advantages and Nature of Hollow Tile	1- 4
Shapes and Kinds of Hollow Tile	5-29

HOLLOW TILE—(<i>Continued</i>)	<i>Pages</i>
Regular, or Box-Shaped, Tile	5-14
T -Shaped Tile	15-19
H -Shaped Tile	20-22
Special Tile	23-27
Surfaces of Tile	28
Strength of Tile	29
Uses of Hollow Terra-Cotta Tile	30-61
Foundations of Hollow Tile	31-32
Exterior Walls of Hollow Tile	33-52
Walls of regular, or box-shaped, tile; Walls of H tile; Walls of T -shaped tile; Veneered walls; Openings in walls.	
Attaching Furring, Trim, Etc., to Walls	53-55
Partitions of Hollow Tile	56
Floor Systems	57-60
Roof Construction	61
Stucco Finish	62-66
Composition of Stucco	62-63
Application of Stucco	64
Finishes	65-66
Examples of Buildings of Hollow Tile	67-82

FIREPROOFING OF BUILDINGS

Introduction	1- 6
General discussion; Principles of fireproofing; Fireproof materials.	
Forms of Fireproof Construction	7-96
The Steel Frame	8-12
Fireproofing With Terra Cotta	13
Fireproofing of Girders and Beams	14-16
Floor Construction of Terra Cotta	17-41
Flat arches; Segmental arches of hollow tile; Gustavino arches; Long-span floor systems.	
Fireproofing Steel and Iron Columns With Terra Cotta	42-45
Tile Partitions	46-48
Tile Roof Construction	49-51

FIREPROOFING OF BUILDINGS

*(Continued)**Pages*

Fireproofing With Concrete	52-65
Concrete floor construction; Fireproofing beams and girders with concrete; Fireproofing columns with concrete.	
Fireproofing With Brick	66
Fireproofing With Metal Lath and Plaster	67-82
Fireproof partitions; Metal lath; Construction of partitions.	
Furring	83-87
Plastering	88
Fireproofing With Plaster Blocks	89
Miscellaneous Fireproofing Materials	89-94
Fire-Extinguishing Methods	95-96

AREAS, VAULTS, AND RETAINING WALLS

Areas	1-32
Area Walls	2-18
Bracing the soil; Walls of terra-cotta tile; Brick walls; Reinforced-concrete walls.	
Area Steps	19-27
Area Floors	28
Area Drains	29-30
Balustrades, Railings, Gratings, and Covers	31-32
Vaults	33-63
Sidewalk Vaults	33-35
Walls of Vaults	36-42
Roofs	43-44
Floors and Sidewalks	45-57
Construction of sidewalks; Concrete sidewalks; Asphalt sidewalks.	
Sidewalk Lights	58-63
Retaining Walls	64-73
Description and Principles of Retaining Walls	64-70
Materials and Construction of Retaining Walls	71-73

PLASTERING

INTRODUCTION

1. Plastering is the process of applying a plastic material known as *plaster* to the surfaces of walls and ceilings so as to produce a neat, smooth, and satisfactory finish. This process is applicable to both the exterior and the interior of the structure. Plaster applied on the exterior of the building is called *stucco*. When applied on the interior of the building it is called *plastering* or *interior plastering*.

Plain plastering consists of covering surfaces with a plain coating of plaster of a uniform finish.

Ornamental plastering is the art of forming plaster ornament in relief upon plain surfaces. This relief is in the form of moldings, ornaments, pilasters, cornices, panels, and other architectural or decorative features which add beauty and dignity to the interior walls and ceilings.

PREPARATION OF THE BASE

SURFACES TO BE PLASTERED

2. Plaster is merely a coating and must be properly supported. It is, therefore, necessary that a suitable foundation, or *base*, be provided to which the plaster can be applied. Such a base exists in the rough surfaces of brick, stone, terra cotta, and other masonry walls. As a rule, however, a base is formed on these walls by means of furring and lathing, to which plaster is applied. In wooden buildings, the base consists of lathing that is applied directly to the frame work of the building.

3. Masonry Walls.—Walls of common brick offer a good surface to which plaster will adhere, especially when the bricks have rough surfaces, and the joints in the brickwork are not entirely filled with mortar. Hollow brick, hollow tile, and gypsum blocks are usually grooved so as to provide a good grip, or base, for the plaster. The surface of stone is not as good as that of brick, but if the stone is rough and the joints are more or less open the plaster will hold to the stonework in a satisfactory manner.

Plaster is generally applied directly to the outside of masonry walls. It is, however, rarely applied to the inside, since water is apt to work its way through a solid wall, and injure the interior plaster.

4. Condensation.—Another objection to plastering directly on the inner surface of a solid masonry wall is that in cold weather the wall becomes cold throughout, including the interior plaster work. When the warm air of the room comes in contact with the cold plaster surface, the moisture in the air is condensed on this surface. This moisture may prove to be very injurious to wall paper, painting, or other decorations that may have been applied to the plaster.

FURRING

5. Methods have been devised to keep condensed moisture from forming on walls, by constructing the walls with hollow spaces in their thickness, or using hollow terra-cotta tiles or hollow bricks. These devices, however, cannot always be depended upon. Consequently, it has become a general practice to fasten wooden or metal strips, known as *furring*, to the inside of masonry walls, to form an air space between the wall and the inside plastering. Furring serves three purposes. It prevents water from working its way through the inside plaster; it prevents condensation of moisture on the inner surfaces of the plaster; and it provides a space back of the lath in which the plaster can form a key.

6. Wooden Furring Strips.—Wooden furring strips, or furring, are shown at *a* in Fig. 1. These strips are usually 1 inch thick by 2 inches wide and are nailed to the wall

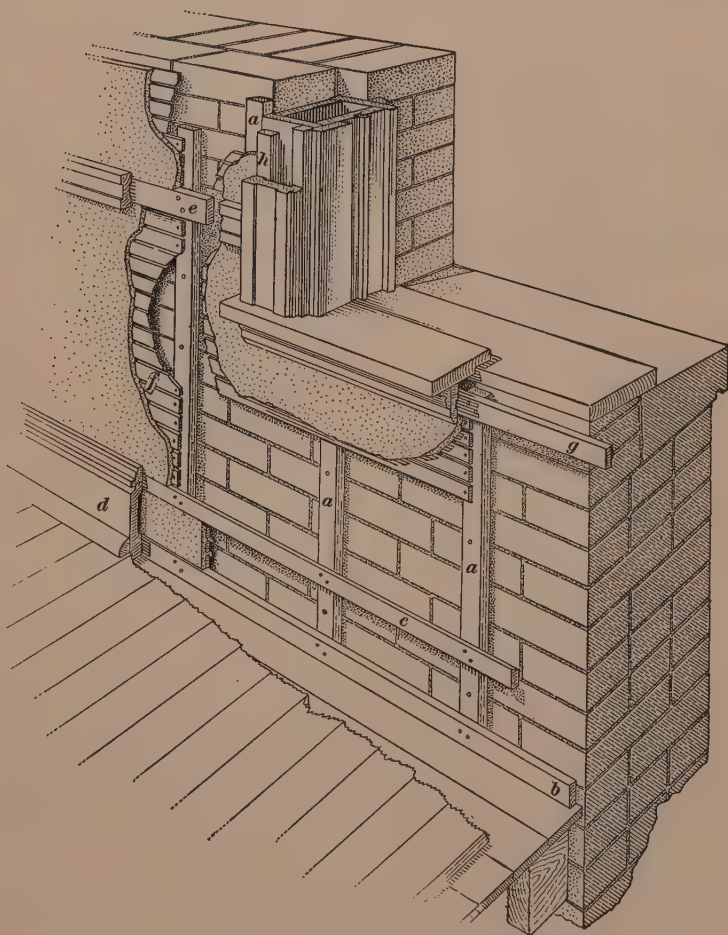


FIG. 1

vertically by a carpenter. These strips are placed either 12-inches or 16-inches on centers.

7. Metal Furring.—Metal furring consists of strips of metal which are attached to the surface of the wall, and to

which lath is applied. Metal furring may be of various standard structural forms, such as small-sized channels,

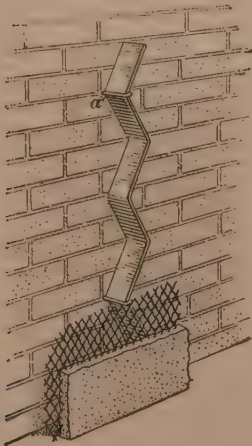


FIG. 2

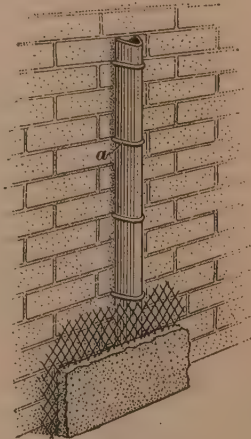


FIG. 3

angles, I beams, or T's, or it may be of forms especially designed for the purpose. In Fig. 2 is shown a simple form of metal furring made by bending a flat strip of metal, which is attached to the wall by means of staples *a*. In Fig. 3 is shown a strip bent into a U-shape, secured to the wall by means of the staples *a*.

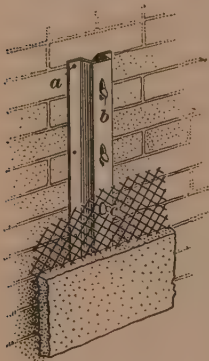


FIG. 4

In Fig. 4 is shown a sheet-steel furring strip which is nailed to the wall through the holes *a* on the sides. The furring holds the metal lath by means of the prongs *b*, which are bent over the lath to hold it in place, as at *c*.

8. Combined Furring and Lathing.—Metal lath, Fig. 5, with raised V-shaped portions, or ribs, is frequently used as the base for plaster on masonry walls. These ribs act as furring, and the separate furring strips are omitted because the sheet part of the lath is separated from the wall sufficiently to form an

air space after the plaster has been applied to the lath. The use of this form of lath and furring is seen in Fig. 6, the fur-



FIG. 5

rings or ribs *a*, being stapled to the brick walls, while the lath surface *b*, is held away from the wall. This form of lath may be applied directly to the exterior sheathing of frame buildings

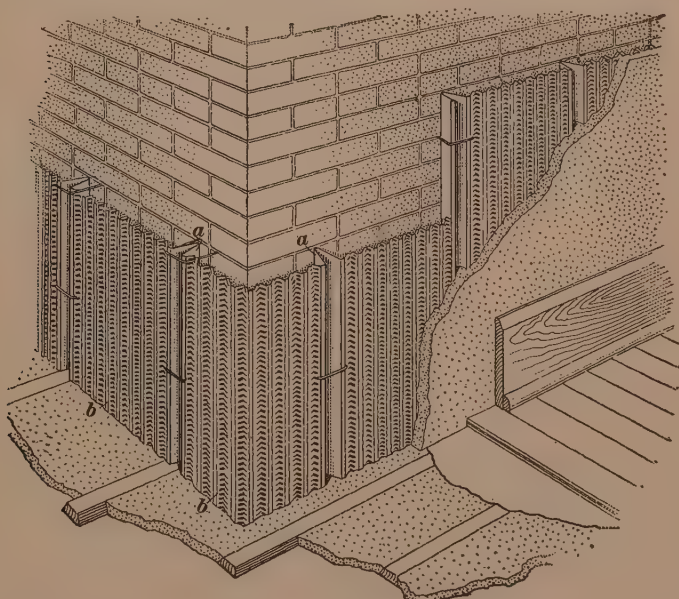


FIG. 6

for the purpose of receiving stucco. This lathing is used also as a support for solid plaster partitions as will be described later.

9. Cross-Furring.—Wooden furring strips *a*, Fig. 7, are sometimes nailed to the under sides of floor joists *b*, in order to make the ceiling level. This process is called *cross-furring*. The under surfaces of the floor joists are not always in the same plane, some being higher than others.

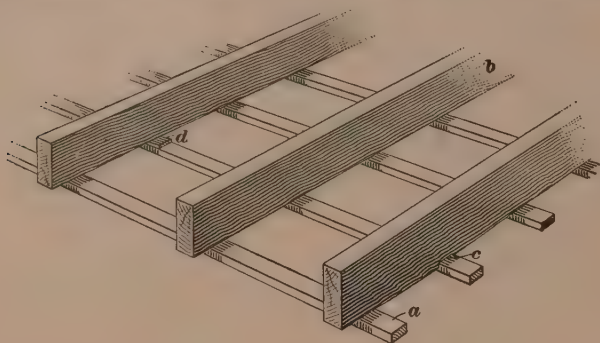


FIG. 7

When this occurs the furring is notched as at *c* when the joists are low, and is wedged down as at *d*, when the bottoms of the floor joists are high. The under surface of the cross-furring is thus made level and ready to receive the lathing and the plastering.

GROUND S

10. Grounds are strips of wood which are applied to walls as guides in plastering and to furnish nailing for the interior trim. Grounds are illustrated in Fig. 1 at *b*, *c*, *e*, *g*, and *h*; also in Fig. 8 at *a*, *b*, *c*, *d*, *e*, and *f*. These grounds must be secured to the wall so that the finished plaster surface will be even with the surfaces of the grounds, and the finished surfaces of the plaster will be even, plumb, and true.

When plaster is applied directly to masonry walls, grounds are applied directly to the masonry. The interior surfaces of such walls are generally uneven and to take up this unevenness the plaster must be made thicker in some places than in others. Grounds applied to such walls must also be varied in thickness. In some places they must be made $\frac{1}{2}$ inch and in

other places an inch or more thick. These thicknesses must be adjusted so that the finished surfaces of the grounds on a wall will be in the same plane and the plaster surface will be even, plumb and true.

As a rule, masonry walls are furred and the grounds are applied on top of the furring as illustrated in Fig. 1. In such cases the thickness of the grounds is determined by the required thickness of the plaster coat, or, more exactly, the distance between the face of the furring and the face of the plaster.

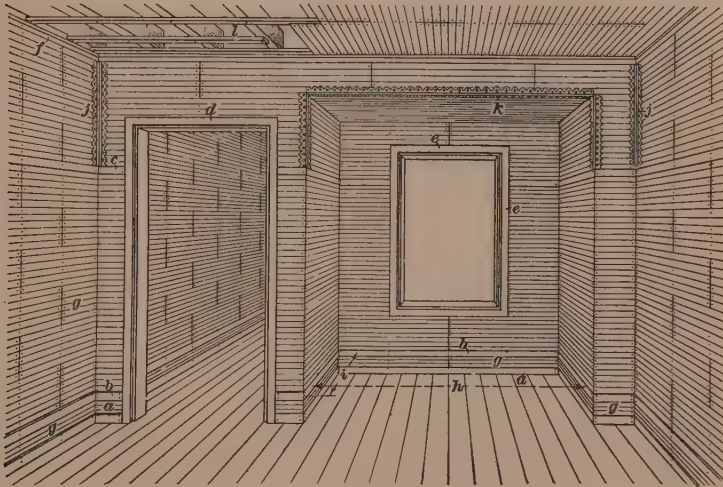


FIG. 8

This, in turn, depends upon the kind of lath used, the kind of plaster applied and the number of layers or coatings of plaster.

11. Thickness of Grounds.—The thickness of the plaster depends upon the nature of the base which supports the plaster or the surface to which the plaster is applied. Thus, for three coats of plaster, which are commonly used, the grounds should be of the following thicknesses: On gypsum block $\frac{1}{2}$ inch; on brick walls $\frac{1}{2}$ inch to $\frac{3}{4}$ inch; on clay tile $\frac{1}{2}$ to $\frac{3}{4}$ inch; on wood or metal lath $\frac{3}{4}$ inch; and on plaster board $\frac{3}{4}$ to $\frac{7}{8}$ inch.

When grounds are used in frame buildings, they are applied directly to the studding and are made from $\frac{5}{8}$ to $\frac{7}{8}$ inch thick.

12. Application of Grounds.—In Fig. 1 is shown a method of applying grounds to a furred wall. In Figs. 9 and 10 grounds are shown applied to stud walls or partitions. It will be seen that the grounds define the limits of the plaster as regards its thickness. At the same time, the grounds are placed so as to afford nailing for the trim.

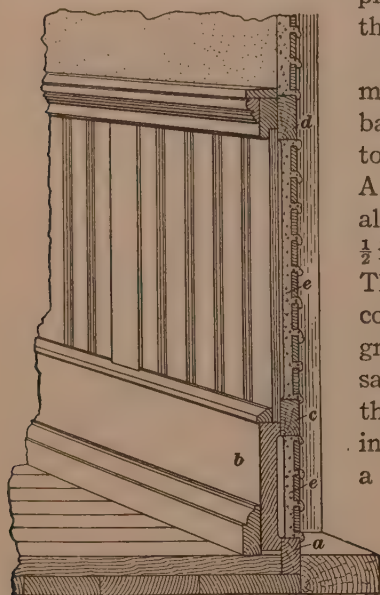


FIG. 9

In Fig. 1 is shown an arrangement of grounds to support a base board. A ground *b* is nailed to the furring *a* at the floor line. A second ground *c* is placed parallel to this strip so as to be about $\frac{1}{2}$ inch below the top of the base *d*. The mold on the base will then cover the joint between the ground *c* and plaster. At the same time, the base board and the top molding can be nailed into this ground. A ground for a chair rail is shown at *e* and is made narrower than the chair rail so that the chair rail will cover the joints between the plaster and the ground.

Grounds applied to hold a wainscot in place are shown at *a*, *c*, and *d* in Fig. 9. The grounds *a* and *c* provide nailing for the base *b*, the ground *c* holding the lower ends of the matched boarding, and the ground *d* holding the upper ends of the boarding as well as the cap of the wainscot.

At *a* in Fig. 10 is a ground for a picture molding and at *b* are grounds that support a wooden cornice. The plastering inside such a cornice need not have the finished coat as it will not be seen.

On stud walls, the lath and one or two coats of plaster should always be carried down to the floor, back of bases, and wainscots, and behind wooden cornices. This, as illustrated in Fig. 9 at *e*, forms a protection against fire and vermin and prevents contact of the wood with the plaster. In Fig. 8 at *g*, lath is shown back of a wainscot and base.

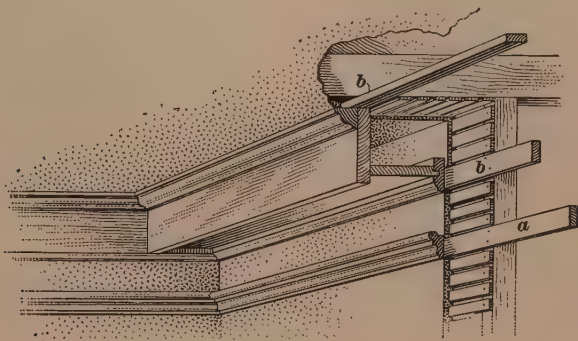


FIG. 10

13. Measuring to Grounds.—When wainscots, paneling, mantels, or other finished woodwork is to be installed in a room, measurements from which to execute such work can be taken as soon as the grounds are in place. The measurements between grounds will be the same as between plaster surfaces. Thus, in Fig. 8, measurements for paneling or wainscoting in the bay, such as at *h* or *i*, can be taken from the grounds. The wainscoting can then be manufactured or *gotten out* while the plastering is being applied.

CORNER BEADS

14. Metal Corner Beads.—When plastered corners are not chamfered or rounded, the angles of plastered walls and piers should be protected by metal *corner beads*, as shown in Figs. 11 to 17 inclusive. These beads furnish grounds for the plaster to finish against, as at *j* and *k* in Fig. 8, and form corners that will not be easily injured.

One form of metal corner bead, applied to a wood lath base, is shown at *a* in Fig. 11. The sides *b* of the bead are

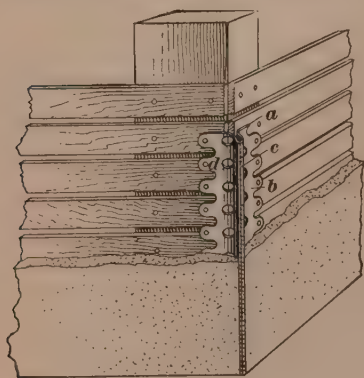


FIG. 11

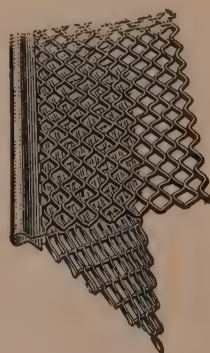


FIG. 12

bent to fit over the corner, and are punched with holes to receive nails by which the bead is attached to its support. The edge *c* of the bead is formed into a shape that will be rigid and will retain a straight edge during the process of plastering, thus forming a true, straight corner. Openings *d* in the sides of the bead permit the plaster to form a key, which prevents the plaster from breaking away from the metal. Another type is shown in Fig. 12, in which the wings are expanded to a form that is securely held by the plaster.



FIG. 13

In Fig. 13 is shown a bead attached to a brick corner, when the plaster is applied directly to the brick. The bead is held in place by wires secured to nails *a* driven firmly into the joints of the brickwork.

The bead shown in Fig. 14 is attached by wires *a* to a construction of metal furring and lath. The holes *b* may be used for nailing when this style of bead is used on a corner of wooden construction.

15. Bull-Nose Corner Beads.—For exposed corners in public buildings, hospitals, and other places subject to hard

knocks, a *bull-nose corner bead*, Fig. 15, is often used. By presenting a rounded metal corner, a bead of this style prevents injury to plaster from shocks or blows which might damage the ordinary metal bead.

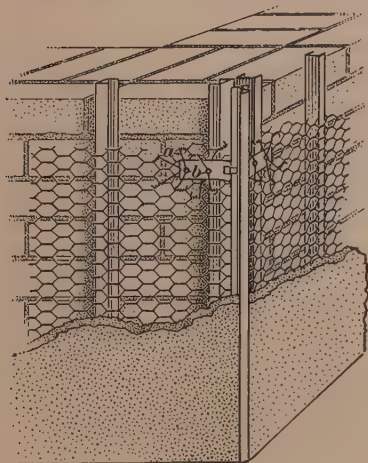


FIG. 14

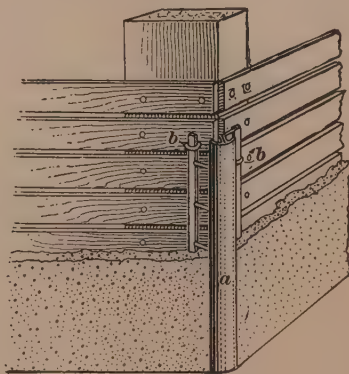


FIG. 15

The nose *a* is usually about $\frac{7}{8}$ inch wide and is curved to a radius of about $\frac{9}{16}$ inch. Bull-nose beads are made in a number of styles which are attached to a wood base by means of staples *b*, or by wires to metal lath.

Metal corner beads for inside angles, as in Figs. 16 and 17, are designed to form a ground against which the plaster may finish, and also to prevent cracks which sometimes occur at inside angles between walls, or between walls and ceilings. Holes *a* in the sides of the bead shown in Fig. 16 permit nailing to wood construction, or wiring to metal lath. The mesh of the sides of the bead shown in Fig. 17 permits fastening by means of wire. Frequently, however, 12-inch strips of metal lath are used in interior angles for reinforcement, as at *a* in Fig. 18, in which case inside beads are not needed. This

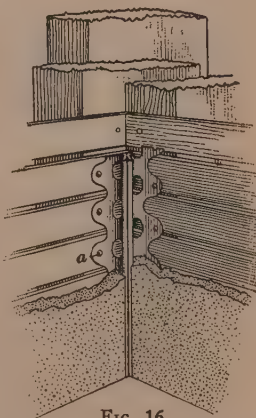


FIG. 16

treatment resists the tendency to crack which occurs at these corners.

Most of the styles of metal corner beads are made in 5-, 6-, 7-, 8-, 9-, and 10-foot lengths. The beads should be set carefully to plumb and straight lines, corresponding to the grounds, and be secured to the supports before the plaster is applied. They should extend in one piece for the whole length of the corner, unless the height is greater than the length in which the bead is made.

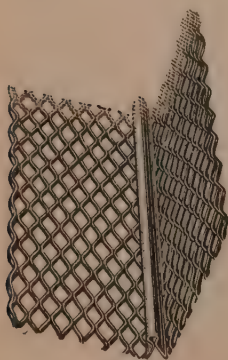


FIG. 17

16. Metal Base Screeds.—*Metal base screeds*, shown in Figs. 19 and 20, are sheet metal shapes used in place of wood grounds, at such places as between cement bases and plastered walls. They make neat joints at the union of the two materials, and assist in bringing each surface to true lines and levels. When the thickness of the cement base is greater than the thickness of the plaster, the cement is brought to the line of the edge *a* in Fig. 19, while

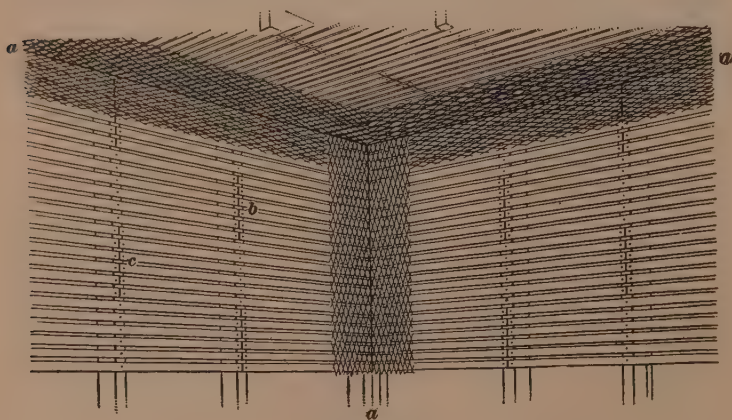


FIG. 18

the plaster is brought to the line *b*. Metal base screeds of the style shown in Fig. 20 are used when the cement base is the

same thickness as the plastering, both surfaces being brought out to the edge of the bead. Metal base screeds of the styles shown in Fig. 19 are attached to wood by means of nails through the holes *c*. On metal lath, wires through these holes will hold the screed

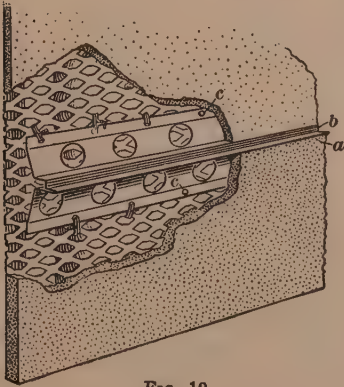


FIG. 19

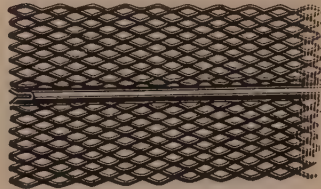


FIG. 20

in place, as shown in the figure. In the style shown in Fig. 20, the screed may be attached through the mesh of the sides.

LATH

17. Lath, or Lathing, is a base which is fastened to walls or ceilings, and is designed to provide a grip, or bond, to which the plaster will hold firmly. Lathing is made of wood strips or of metal in various forms.

WOODEN LATH

18. Common Lath.—Common wooden lath is made of white pine, fir, spruce, red cedar, hemlock, and yellow pine. The wood is sawed into strips $1\frac{1}{2}$ in. $\times$ $\frac{1}{4}$ in. $\times$ 32 in. or 48 in. The 32-inch length is designed for application to furring strips, joists, and studs that are set to the standard spacing of 16 inches on centers. The 48-inch lath, which is the more commonly used, may be used with 12-inch spacing, as well as with 16-inch spacing. Lath 1 inch wide and $\frac{1}{2}$ inch thick are recommended by some manufacturers as a base for stucco.

Lath $\frac{3}{8}$ inch thick may be obtained in some localities, and these can be used either for plaster or stucco.

All lath should be straight-grained to prevent their warping, due to the absorption of moisture from the plaster. They should be free from rot or decay to insure durability, clear of shakes, large or loose knots that will reduce their strength, and free from bark and resin pockets which may cause subsequent discoloration of the plaster.

Lath which are half-green, or only partially seasoned, are considered best for gypsum and cement plasters. Those used with lime plaster should preferably be well seasoned.

Common lath are sold by the thousand, one thousand lath 48 inches long being estimated to cover from 60 to 75 square yards of surface, depending upon the width of the spaces between the lath, and the number and size of the openings in the walls.

19. Application.—Common lath are nailed to the supports in parallel rows, as shown in Fig. 8, spaces being left between the sides and ends of the lath through which the plaster may be pressed to form a key which will hold the plaster firmly in place. When lime plaster is used, the lath applied to the ceiling joists should be spaced $\frac{3}{8}$ inch apart, and on the side walls, the lath should be spaced $\frac{1}{4}$ inch apart. For gypsum plaster, many of the manufacturers recommend spacing the lath not over $\frac{3}{8}$ inch apart, especially on ceilings, while some suggest that the lath should not be over $\frac{3}{16}$ inch apart on side walls. Some magnesite stuccos hold best when the lath are spaced only $\frac{1}{8}$ inch apart. Care must be taken to space the lath evenly.

The ends of the lath should not lap over one another, but should be placed end to end and about $\frac{1}{4}$ inch apart. Continuous joints between the ends of the lath should not occur on one support, but the lathed surface should be divided into panels about 15 to 18 inches in height, as shown at *b* in Fig. 18. The vertical joints of these panels should break on alternate supports, as at *b* and *c*, or else continuous cracks in the plaster will be liable to form in front of these joints. Lath are

usually attached to joists and studs with cut or wire nails about $1\frac{1}{8}$ inches long, which have large flat heads, and one nail is used at each support.

20. Lath on Wide Surfaces.—Where joists, studs, or girders are over 2 inches in width, strips of lath, as shown at *a* in Fig. 21, should be attached to the surfaces to allow space for the plaster to form a key. Cross-furring may be applied to

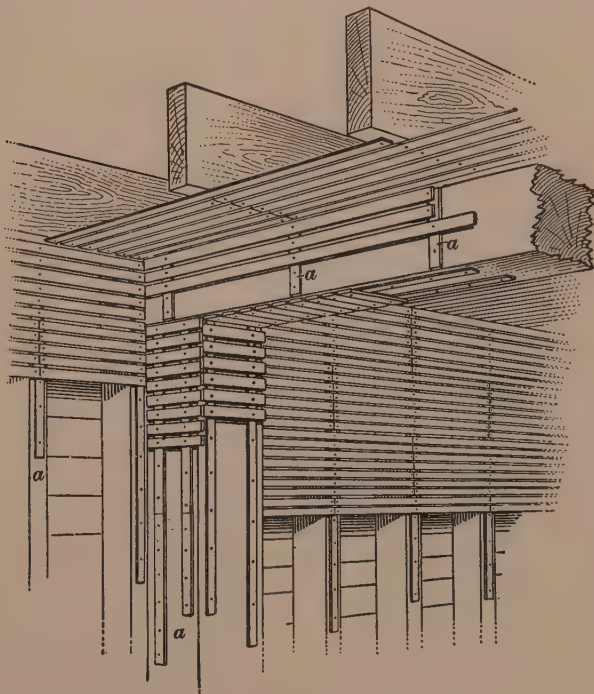


FIG. 21

thick joists, as at *l* in Fig. 8. Nails are sometimes studded thickly over wide surfaces of wood, such as beams, in order that the plaster may form a clinch around the heads of the nails. This is done instead of stripping.

21. Lathing for Back-Plastering.—The outside walls of frame houses are sometimes *back plastered* to help keep out the cold. *Back-plastering* consists of installing a lath base

between the studs, and coating this base with plaster. This form of construction is shown in Fig. 22. The vertical furring strips *a* are attached to the studding *b*, and the lath *c* are attached to these strips. The lath are separated from the outside boarding, or sheathing *d*, by means of these strips *a*, and a suitable space is provided in which the plaster may form a key, as shown at *e*. The air space between the sheathing *d* and the back-plastering acts as insulation to prevent the passage of heat and cold.

22. Sheathing Lath.—A combined sheathing and lath, known as *Byrkit lath*, is shown at *f* in Fig. 22. This lath

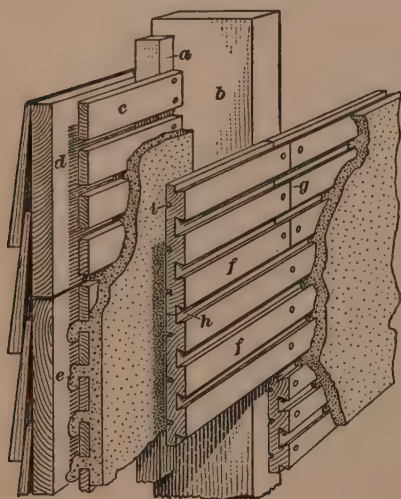


FIG. 22

consists of boards $\frac{3}{4}$ inch in thickness, containing grooves *h*, and is made in widths of $3\frac{1}{2}$ and $5\frac{1}{2}$ inches. The lath is made in lengths of 4 feet and upwards. Plaster is bonded to Byrkit lath by filling the dovetail-shaped grooves *h*. The back of the lath is also grooved, as shown at *i*, to prevent the lath from warping and splitting. The end joints of this lath are made on the support, as at *g*.

The use of this form of lath adds great stiffness to the frame of the building, especially when long lengths are used. Sheathing may be omitted when this lath is used. Thin partitions may be made by using this lath on both sides of 2-inch studs. The lath is also useful for plastering sliding-door partitions, since no lining of the pockets is required. Nails can be driven anywhere in the lath without loosening the plaster.

23. Assembled Wooden Lath.—A form of lath known as *Bishopric Board* is shown in Fig. 23. This lath consists

of a waterproof fiber board *a* covered on one side with a waterproof coating *b* known as *asphalt mastic*. Creosoted wooden lath having beveled edges, as shown at *c*, are applied and the whole subjected to pressure, which causes the lath to adhere firmly to the board *a*. The asphalt coating makes the board both water- and air-tight. The dovetail spaces between the laths provide excellent keys for the plaster.

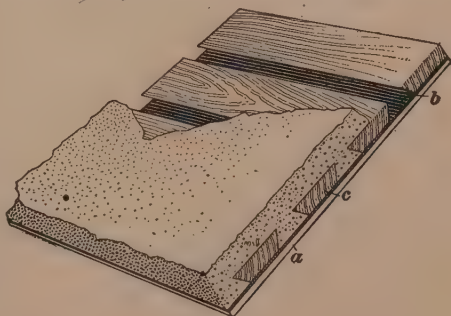


FIG. 23

Bishopric board is shipped in rolls, each roll containing one sheet 4 feet wide and 25 feet long.

METAL LATH

24. Forms of Metal Lath.—Steel and iron sheets and wire are worked into forms that may be used as bases for plastering. When made from sheets, the product is known either as *expanded-metal-lath*, as shown in Fig. 24, or as *sheet-metal lath*, as shown in Fig. 25. When made of wire, the product is called *wire lath*, or *metal fabric*, and is shown in Fig. 26.

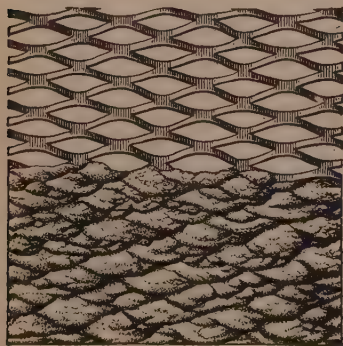
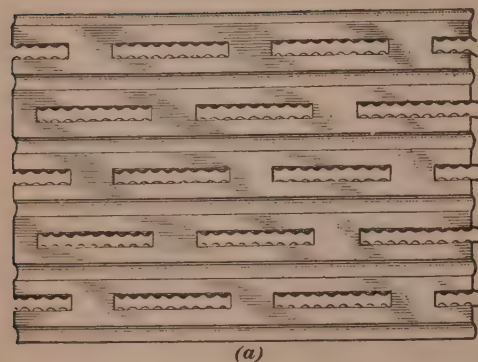


FIG. 24

25. In Fig. 24 is shown the back of a panel of expanded-metal lath, showing the key after plaster has been applied to the lath. In Fig. 26 is shown a panel of wire lath similarly treated.

In Fig. 25 (a) is shown a panel of sheet-metal lath, and in (b) the reverse side of the same lath after plaster has been applied to it.



(a)



(b)

FIG. 25

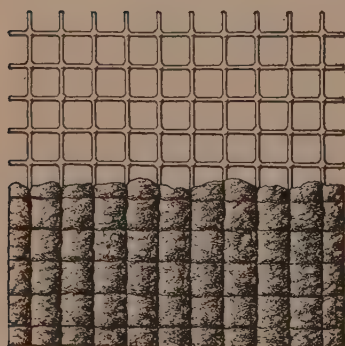


FIG. 26

26. Protecting Metal Lath.—

Steel is subject to corrosion on exposure to moisture. No metal lath, manufactured from steel, is now sold unless protected by a preservative paint covering, or by being galvanized. When steel is fully embedded in plaster there is little danger of corrosion except in positions where the plaster itself is not suitable, as in damp situations. In such positions Portland cement plaster should be used, and it should fully embed the lath. Metal lath is also made of rust-resisting

metal such as pure iron or copper-bearing steel.

EXPANDED-METAL LATH

27. Expanded-metal lath derives its name from the process of manufacture. Sheets of metal are first slit and then expanded so that a mesh is formed, through which the plaster may pass and form a key. Expanded metal is made in

sheets from 16 to 24 inches in width, and usually 96 inches in length.

28. Plain expanded-metal lath is shown in Fig. 27. As in (a) it is called the *diamond mesh*; in (b), the *oblong mesh*;

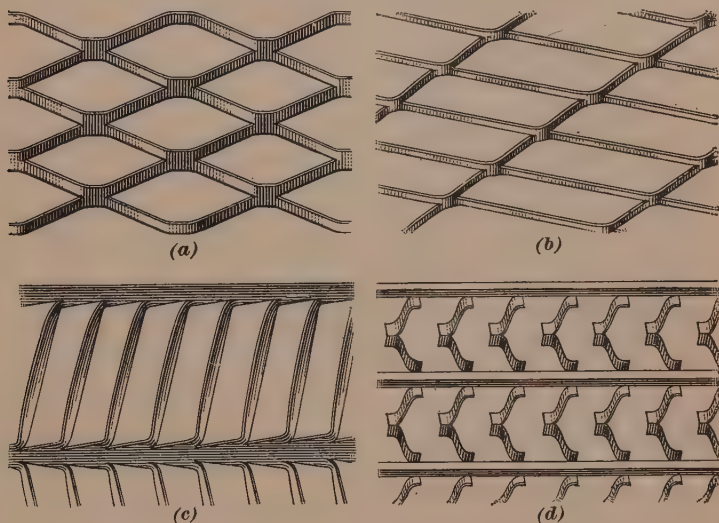


FIG. 27

in (c), the *herringbone lath*, and in (d), the *hy-rib lath*. There are many styles of expanded-metal lath, made in several

TABLE I

MINIMUM WEIGHTS OF METAL LATH PER SQUARE YARD

Interior Work			
Expanded metal	Walls and partitions	Studs 12 in. on centers	2.20 lb.
Expanded metal	Walls and partitions	Studs 16 in. on centers	2.50 lb.
Expanded metal	Ceilings	Joists 16 in. on centers	3.00 lb.
Exterior Work			
Expanded metal	Any position	Supports 16 in. on centers	3.40 lb.
$\frac{3}{8}$ in. rib lath	Any position	Supports 24 in. on centers	3.00 lb.
$\frac{3}{8}$ in. rib lath	Any position	Supports 30 in. on centers	3.50 lb.
$\frac{3}{8}$ in. rib lath	Any position	Supports 36 in. on centers	4.00 lb.

be of wood, of rolled structural shapes, such as channels or angles, as shown at *a* in Fig. 28, or of sheet-metal shapes, as at *a* and *b* in Fig. 29. The lath is attached to wood supports by $1\frac{1}{4}$ inch galvanized staples which are driven through the meshes of the lath at about 6-inch intervals at every support.

When applied to metal supports, the lath is wired to the supports or fastened with clips. Three styles of clips are shown in Figs. 30, 31, and 32. The prongs *a* in Figs. 30 and 31 are intended to fit over the flange of an I beam, while the prongs *b* extend through the lath and are bent so as to hold the lath securely. The prongs *a* and *b* in Fig. 32 may all extend through the lath and be bent around the support, or two of the prongs, as the prongs

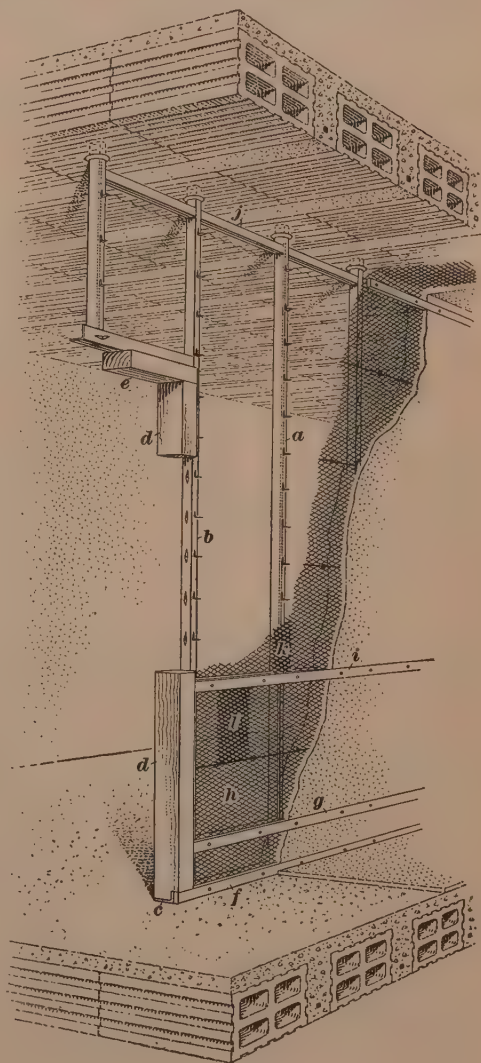


FIG. 29

a may be used to go around the support, while the other two may be bent back to go through the lath and hold it in place.

The sheets of lath are placed horizontally on the studding, the horizontal edges being lapped 1 inch or less. The edges are tied together with wire

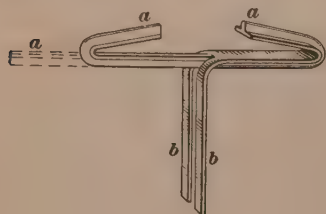


FIG. 30

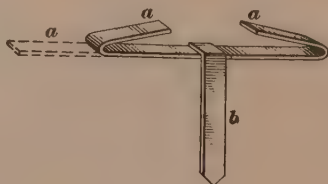


FIG. 31

and the lath is fastened to every stud. Where the ends of the sheets meet over a stud, as at *k* in Fig. 29, they are lapped about 2 inches and wired together and to the studs. Where the ends meet between the studs, as at *l*, they are lapped 8 inches and wired together.



FIG. 32

SHEET-METAL LATH

30. Metal lath, made of steel sheets which are punched out, or expanded in some parts in order to form a good key for the plaster, is classed as *sheet-metal lath*. The lath is made in plain flat sheets for ordinary lathing.

31. Forms of Sheet-Metal Lath.—A form of plain perforated sheet-metal lath is shown in Fig. 33. This lath, known as the *Sykes lath*, has ridges *a* about 2 inches apart. Portions *b* are punched out to form openings and loops *c*. Another form of sheet-metal lath is shown in Fig. 25. The *Bostwick*, or *Truss-Loop* lath has truss-like loops.

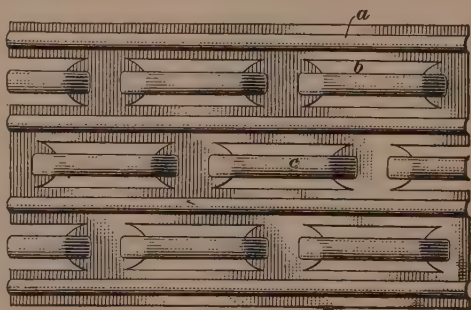


FIG. 33

32. Characteristics of Sheet-Metal Lath.—Sheet-metal lath is very rigid, and forms a stiff base on which to apply plaster. The openings in the sheet being smaller in proportion to the solid surface, less plaster is forced through the lath than with either wire or expanded-metal lath. The back cannot be covered with plaster and is therefore exposed to corrosion.

33. Application of Sheet-Metal Lath.—In general, the application of sheet-metal lath is similar to that for expanded-metal lath, except that nails are generally used in place of staples. The lath may be attached to wood supports, such as furring, joists, or studs, or to metal supports.

WIRE LATH

34. Plain Wire Lath.—Plain wire lath, sometimes called *metal fabric*, consists of wires that are woven together to form square or rectangular meshes. The wires are usually spaced $\frac{1}{10}$ inch on centers, leaving spaces about $\frac{3}{8}$ inch square, and producing what is technically termed *two-and-one-half mesh to the inch* (five wires to 2 inches). The wire is No. 20 gauge, the diameter of the finished material being .035 inch. Another spacing is two mesh to the inch ($\frac{1}{2}$ inch on centers), the lath being made of No. 18 gauge wire, which is .047 inch in diameter.



FIG. 34

35. Stiffened Wire Lath.

Wire lath is better when stiffened so that it will not yield when the plaster is applied. Stiffeners are therefore woven

into the lath at intervals of $7\frac{1}{2}$ to 8 inches. These stiffeners are in the form of round rods, or of V-shaped strips as illustrated at *a* in Figs. 34 and 35. This stiffening is part of the lath and does not take the place of furring.

In Fig. 34 is shown a panel of V-stiffened lath before the plaster has been applied, and in Fig. 35 is shown a back view

after the plaster has been applied. The metal is entirely embedded in the plaster, and is thus protected from rusting.



FIG. 35

Wire lath, both the plain and the stiffened, is furnished usually in rolls 150 feet in length, the stock width of the lath being 36 inches. When plain lath is to be used, the supports to which it is applied should be spaced not over 12 inches on centers, while if the stiffened lath is used the supports may be 16 inches on centers.

36. Application of Wire Lath.—In applying plain wire lath to wooden supports, $\frac{3}{4}$ -inch round-top staples, as shown in (a), Fig. 36, are used generally, and fastenings are made at 6-inch intervals. The stiffened lath should be secured at each stiffener by means of $1\frac{1}{4}$ -inch staples of the form shown in b. These staples will span the stiffeners. Lath that is applied to metal supports should be tied with No. 18 gauge galvanized annealed wire, plain lath being secured at 6-inch intervals, and stiffened lath secured at each stiffener. The lath should be lapped about 6 inches around corners and angles to minimize the cracking of plaster at such places.

37. Characteristics of Metal Lath in General. Metal lath is extensively used in fireproofing, and is valuable also in wood frame construction from the fact that plaster applied to metal lath is not liable to be injured by the usual shrinkage of the framing timbers. Plaster becomes firmly attached to all forms of metal lath, and ordinary accidents will not cause it to break away or become loosened. Metal lath is peculiarly adaptable to suspended ceilings, lending itself readily to bending into shapes to conform to the various moldings, panelings, etc., of an ornamental ceiling.

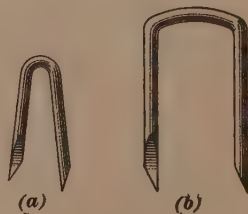
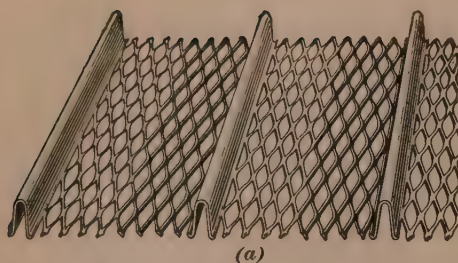


FIG. 36

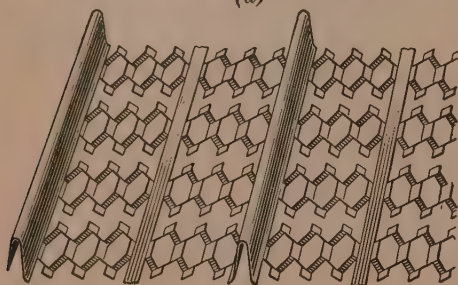
In frame construction, metal lath gives to the plastered wall and ceiling two vital qualities, namely: permanence, or resistance to cracks, and resistance to fire. There are certain portions of buildings, notably dwellings, that are more vulnerable than others, and metal lath can be used in these places or parts at very little extra expense. Thus, metal lath may be used to prevent cracks in the plaster on the ceilings of prominent rooms, and it may be bent around and lapped 6 inches on either side of wall and partition angles, and around door bucks. It may be placed back of wainscots and tile mantels, across ducts for plumbing and heating plants, or as a foundation for stucco.

For use as fire-stops, or to prevent the spread of fire, metal lath may be used on all bearing partitions, and on all exterior walls. The bases of such partitions and walls may have metal-lath baskets for holding incombustible materials. Metal lath may be used for ceilings under much used rooms, and especially when the ceilings are over heating plants and coal bins. At chimney breasts and flues, and back of kitchen ranges, metal lath tends to prevent fire or heat from reaching the woodwork. Stair walls and soffits may be covered with metal lath. The use of metal lath for exterior walls will aid in preventing fire from reaching the woodwork of the building from the outside.

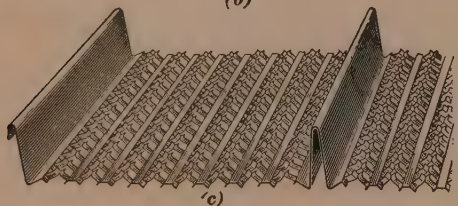
Wire lath and expanded-metal lath, as will be seen by reference to Figs. 24, 25, and 26, require more plaster than wooden lath or sheet-metal lath. This, however, is an advantage, for the plaster, which is a fireproofing material, nearly or completely encloses the lath, protecting it both on the face and on the back from exposure to fire and moisture. Metal lath entirely embedded in plaster will protect woodwork from fire for a considerable time. For this reason it should be placed back of ranges and stoves and their pipes, and should be separated by metal furring at least $\frac{3}{4}$ inch from the woodwork it is to protect. The Underwriters Laboratories, representing the fire insurance companies of the United States, consider that metal lath and plaster will protect woodwork from fire for a period of at least one hour.



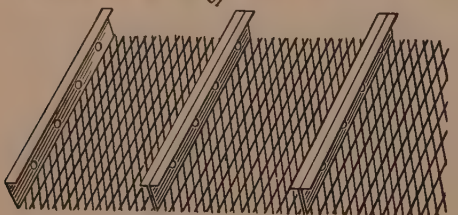
(a)



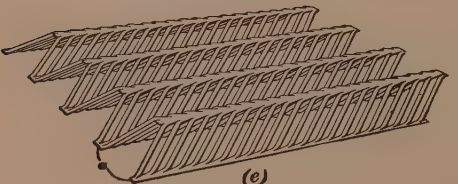
(b)



(c)



(d)



(e)

FIG. 37

REINFORCED OR RIBBED METAL LATH

38. Most of the forms of metal lath already shown are also manufactured with ribs or projections which are designed to act as furring or even as studs. This material, while here classified as metal lath, is better described as combination furring and lath and combination studding and lathing.

39. Reinforced Expanded Metal.

In Fig. 37 are shown several examples of expanded metal having ribs of various designs. When the ribs are small, as in (a) and (b), they act as furring strips. The use of this material as combination furring and lath is illustrated in Fig. 6. Its use as combination lathing and studding is shown in Fig. 38. In this case the metal is entirely embedded in the plaster, which is 2 or more inches thick.

The styles of reinforced expanded metal lath shown in (a), (b), and (c) in Fig. 37 have V-shaped ribs of different heights. A material known as *Chanelath* is shown at (d). This has T-shaped ribs spaced at intervals of 4 to 8 inches.

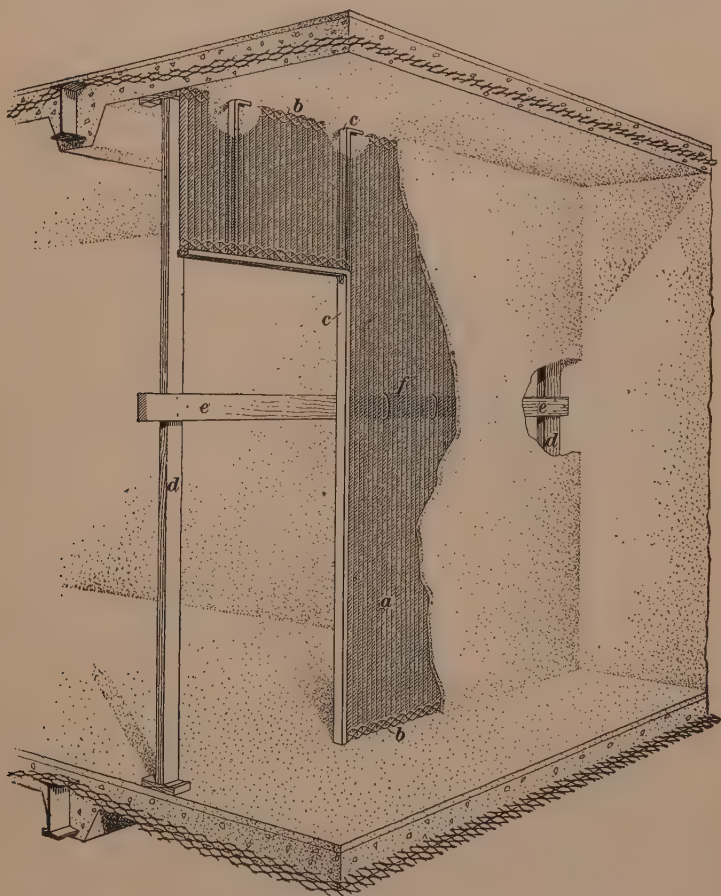


FIG. 38

Trussit (e) is a herringbone lath bent so as to be quite stiff. It is adapted to forming partitions and is embedded in solid plaster from 2 to $3\frac{1}{2}$ inches thick.

Fig. 38 illustrates the application of trussit to a solid partition. The trussit, a, is fastened to the floor and ceiling by the

metal forms *b*. Metal studding *c* must be used around door or other openings. Temporary bracing *d* and *e* is wired to the lath as at *f* to hold the partition until the plaster is in place.

The forms of reinforced lath shown in (a), (b), (c), and (d), Fig. 37, are used as furring and lathing. The ribs are usually spaced from 4 to 8 inches apart and are from $\frac{5}{16}$ to $1\frac{1}{2}$ inches high.

40. Reinforced or Ribbed Sheet-Metal Lath.—Most forms of sheet-metal lath are also made with deep ribs, usually spaced 4 or 8 inches on centers, similar in character and purpose to those described for expanded-metal lath. These ribs

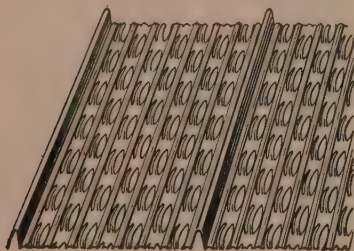


FIG. 39

take the place of furring on masonry walls. One form of ribbed sheet-metal lath is shown in Fig. 39.

As the ribbed sheet-metal lath is made usually with a rib at each edge, the sheets are lapped only the width of the rib. Staples should be used over the ribs, the length

of the staple being about 1 inch more than the height of the rib.

Wire lath is not made with ribs as is done with expanded-metal or sheet-metal lath, and so it must be supported on furring or studding of metal or wood.

41. Application of Ribbed Metal Lath.—Joints between sheets of ribbed lath are formed by lapping the edge of one sheet over that of the sheet previously applied. The edges are then wired together and secured to the supports. In the case of Chancelath, shown in Fig. 37 (d), the edges of the sheets are butted together and wired. Where the ends of the sheets occur over supports, the lap is usually made 2 inches, otherwise a lap of 8 inches should be made, and the sheets wired together.

Ribbed forms of expanded-metal lath are adapted for use as a combined furring and lathing on masonry walls, as shown in Fig. 6. When used as bases for plaster to protect woodwork

against injury by fire, the ribs are fastened to the wooden supports, the remaining part of the lath being separated from the wood surface.

42. Lath for Solid Partitions.—To economize space, partitions between rooms or offices are sometimes made as thin as possible. In Fig. 28 the studs *a* are $\frac{3}{4}$ in. hot- or cold-rolled channels. In Fig. 29 at *a* is a U-stud, and at *b* an angle stud which forms the jamb of the door. A similar angle forms the head of the door. These studs are fastened to the floor by means of a socket strip *c* and the tops are let into the ceiling. Wooden bucks *d* and *e* are secured to the angle studs by means of screws or bolts. Metal lath is stretched over the studs, the strips being placed horizontally. Grounds to which the base board may be fastened are shown at *f* and *g*. These grounds are placed on both sides of the metal lath *h*, and are nailed through into each other. The grounds *i* and *j* provide nailing places for a chair rail and for a picture molding. Upon this base the plastering is applied on both sides, and brought to the faces of the grounds.

PLASTER BOARDS AND WALL BOARDS

43. Plaster boards are made of alternate layers of gypsum plaster, containing fiber, and strong fibrous felt, and are used as a substitute for lathing and the first coat of plaster. They are sometimes made with an interior core of gypsum mixed with fiber and with felt on the outside. This material is made in sheets generally 32 by 36 inches in size and from $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness. The board used for plastering should not be less than $\frac{3}{8}$ inch thick. The outer surfaces of felt form a perfect bond with the plastering mortar. These boards can be readily sawed and nailed and are fastened directly to the studs, furring, or joists. The nails to be used are flat-headed nails $1\frac{1}{4}$ inches in length which are coated to prevent rust. These boards should be set about $\frac{1}{4}$ inch apart at the edges and should break joint horizontally. They should be nailed every 6 inches along the edges.

44. The advantages of using plaster boards are that they are non-conductors of heat and cold, and are fire-resisting. They save the expense of the lathing and the first coat of

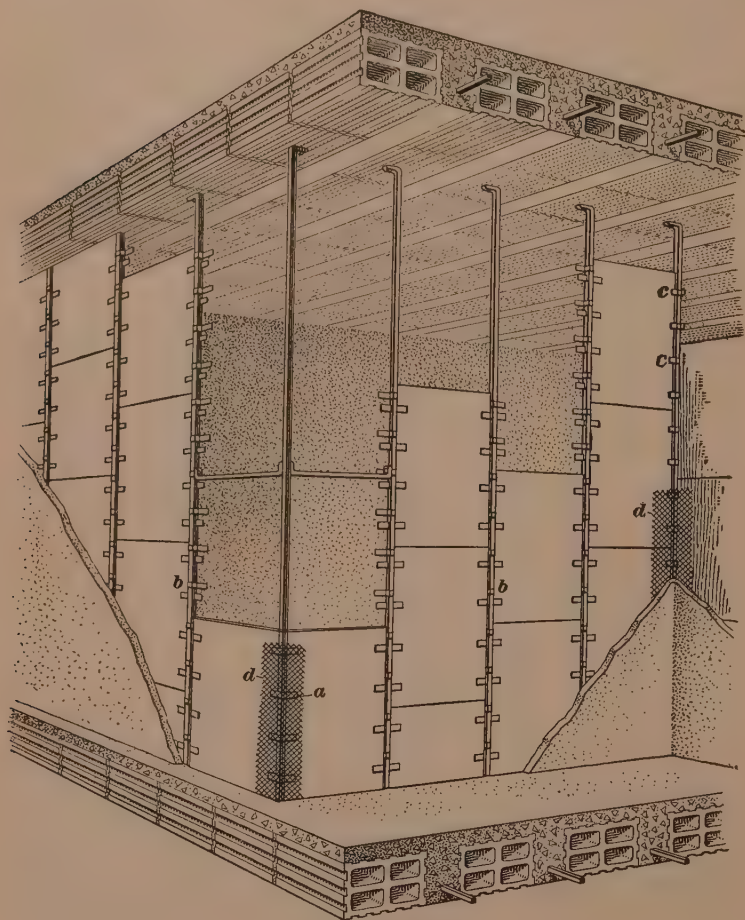


FIG. 40

plaster and avoid the moisture due to this coat of plaster. The time required for the first coat of plaster to dry is saved.

Wall boards are similar to plaster boards but are not plastered. They should be put on the studding, or furring,

so as to produce a paneled effect. The joints may be covered with wooden strips or else filled with a gypsum plaster and the entire surface papered. Wall boards are made 32 inches and 48 inches wide, and from 7 to 10 feet in length so that there will be as few joints as possible.

45. Solid Partitions.—Solid partitions may be made by fastening the plaster boards to channel supports, as shown in Fig. 40. The sheets commonly used for this purpose are 32 inches wide and 36 inches high. Clips, as shown in Fig. 41,

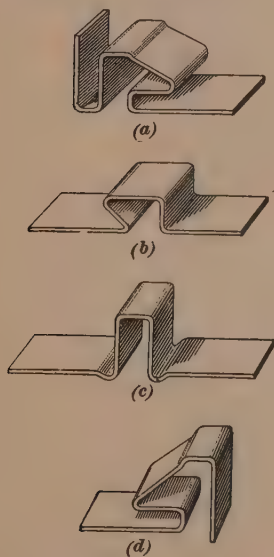


FIG. 41

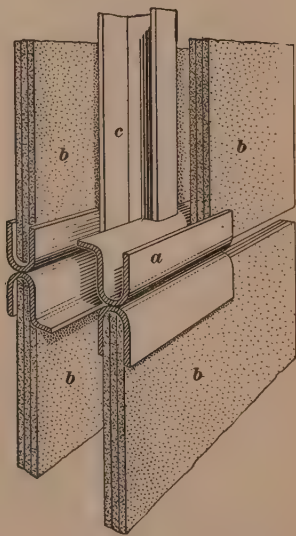


FIG. 42

are used to fasten the boards firmly to the supporting channels. The clip (a) is a corner clip, used in places as at a in Fig. 40. The clips (b) and (c), in Fig. 41, are used together in the plain surface, as at b in Fig. 40. Clip (d), Fig. 41, is used against walls, as at c in Fig. 40. These clips are spaced about 6 to 8 inches apart. To minimize shrinkage at corners, metal lath may be bent into angles or over corners, as at d, Fig. 40.

46. Hollow Partitions.—Hollow partitions may be built by nailing plaster boards to both sides of wooden

studding. When the studs are of metal, the boards may be held in place by clips. Fig 42 shows a portion of such a partition, the clip *a* holding the boards *b* to the channel stud, *c*.

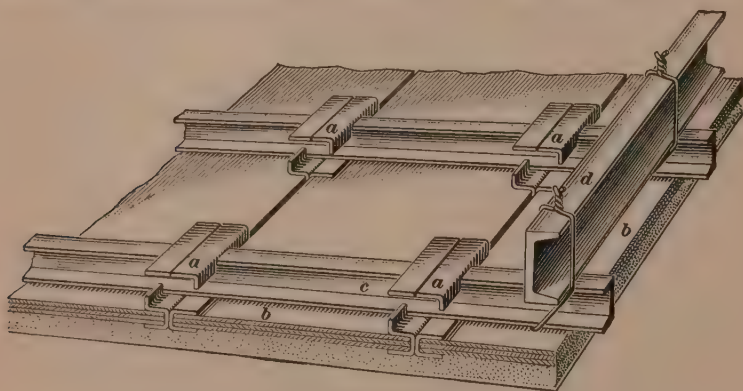


FIG. 43

47. Suspended Ceilings.—Plaster boards may be used for suspended ceilings by the use of clips *a*, in Fig. 43, which hold the boards *b*, the clips being attached to channels *c*, suspended at 16-inch centers from the carrying channels *d*.

INTERIOR PLASTERING

PLAIN PLASTERING

48. Preparation for Plastering.—The carpenters' specifications require, usually, that all surfaces shall be properly prepared for lath and plaster, and that suitable plaster grounds, such as are shown in Figs. 1 and 8, and at *a* in Fig. 44, shall be affixed to the masonry, or framework. Before plastering, the plasterer should test the alinement of the walls and ceilings, to see if there are concave surfaces which will require the application of an excessive thickness of plaster to bring the plaster to a plane surface. Also, to find out if there are places where the lath come too close to the finished surface, so that only a very thin coat of plaster can be applied. Where these irregularities occur, the lathing

should be removed, and the surfaces brought to true planes by blocking out, or cutting back, the furring strips under the lath.

Metal lath should be examined carefully to see that it is rigid, so that it will not buckle when the plaster is applied. The joints should be inspected to see that they are all properly fastened. The lath should be laid so as to afford a secure hold for the plaster, and the weight and finish of the lath should be checked to see that they are in accordance with the architects' specifications.



FIG. 44

Walls of masonry, hollow tile, or gypsum blocks should be plumb and true, especially if the plastering is to be applied directly to them. Walls that do not come out to their true planes may be made to do so by means of Portland cement mortar or gypsum plaster.

Plastering on wooden lathing should be begun as soon as possible after the lathing is completed. When such lathing stands too long, it is apt to dry out, making it necessary to wet the lath before plastering can be done.

When gypsum or cement plaster is to be applied to wooden lath, the lath, unless they are green, should be well watered, not merely sprinkled, a few hours before plastering, so that the lath will swell before the plaster has begun to set. When the lath are too dry, they will absorb moisture from the plaster, and swell after the plaster has begun to set, causing the plaster to crack and check.

Masonry surfaces, such as brick, concrete, tile, or gypsum blocks, upon which plastering is to be applied, should be brushed to remove all traces of dust, dirt, or loose particles, and sprinkled with water before applying the plaster. Too much moisture will prevent the proper adhesion of the plaster while, if too little is used, the walls will absorb too much water from the plaster, which then will dry out too fast. A good rule is to have the masonry as wet as it can be and leave no water standing on the surface. Whenever possible, in old work, the mortar joints of the masonry should be raked out to form a key for the plaster. In new work, it is necessary only to leave the joints roughened with the trowel but not struck.

49. Protection from Weather.—After it is on the wall, it is sometimes necessary to give the plaster protection from the weather, if the permanent sash are not in place. In hot, dry, and windy weather, plaster should be protected from air currents by closing the windows with muslin screens. With some quick-setting plasters, the surface should be sprinkled with water to prevent the plastering from drying out too much before it has set. In freezing weather, plaster must be protected from frost until it has set, or become hard. Usually, unless the regular sash are in place, it is the duty of the carpenter to close temporarily all of the openings in the outside walls with old sash, cloth screens, or other suitable materials. Temporary heat is also an advantage in cold weather. This can be easily provided if the heating apparatus of the building is installed. After the plastering has set, the doors and windows should be kept open, if the weather is not too cold, so that the plastering will thoroughly dry out.

PLASTERERS' TOOLS

50. The implements used by the plasterer are simple and inexpensive, the principal ones being shown in Fig. 45.

In (a) is shown an ordinary *screen*, which is used for separating the coarser particles of sand and gravel from the finer ones. In (b) is shown a screen through which slaked lime is passed to free it from grit and unslaked particles.

51. The *hoe* and the *shovel*, shown in (c) and (d) respectively, are used for mixing the materials.

52. The *hawk*, shown in (e), is a piece of board about 10 inches square, provided with a short handle. It is used to hold small quantities of plaster, ready for applying with a trowel.

53. The ordinary *laying trowel*, shown in (f), is used for applying plaster to the walls. It is a thin plate of polished steel, about 10 inches long and $4\frac{1}{2}$ inches wide, having a wooden handle. Various other forms of trowels, for gauging, pointing, etc., varying in length from 3 to 7 inches are shown in (g), (h), and (i).

54. *Floats* are used for smoothing, or *floating*, the surface of the second coat. In (j) is shown the *hand float*, which is merely a piece of board with a handle on the back. It is made usually of pine, but for producing the finished surface of very fine work, a cork face is sometimes used. For rough finish, the face of the float is covered sometimes with burlap, felt, or carpet. A *two-handled float*, called a *derby*, is shown in (k); this is a straightedged piece of wood, usually from 3 to 6 feet long, used for floating larger surfaces than can be worked readily with a one-handled float.

55. The *straightedge*, shown in (l), is a long piece of smooth board, having its under edge planed straight and true. It is used to test the walls and ceilings, in order to obtain plane surfaces.

56. The *square*, shown in (m), is used for testing the trueness of angles.

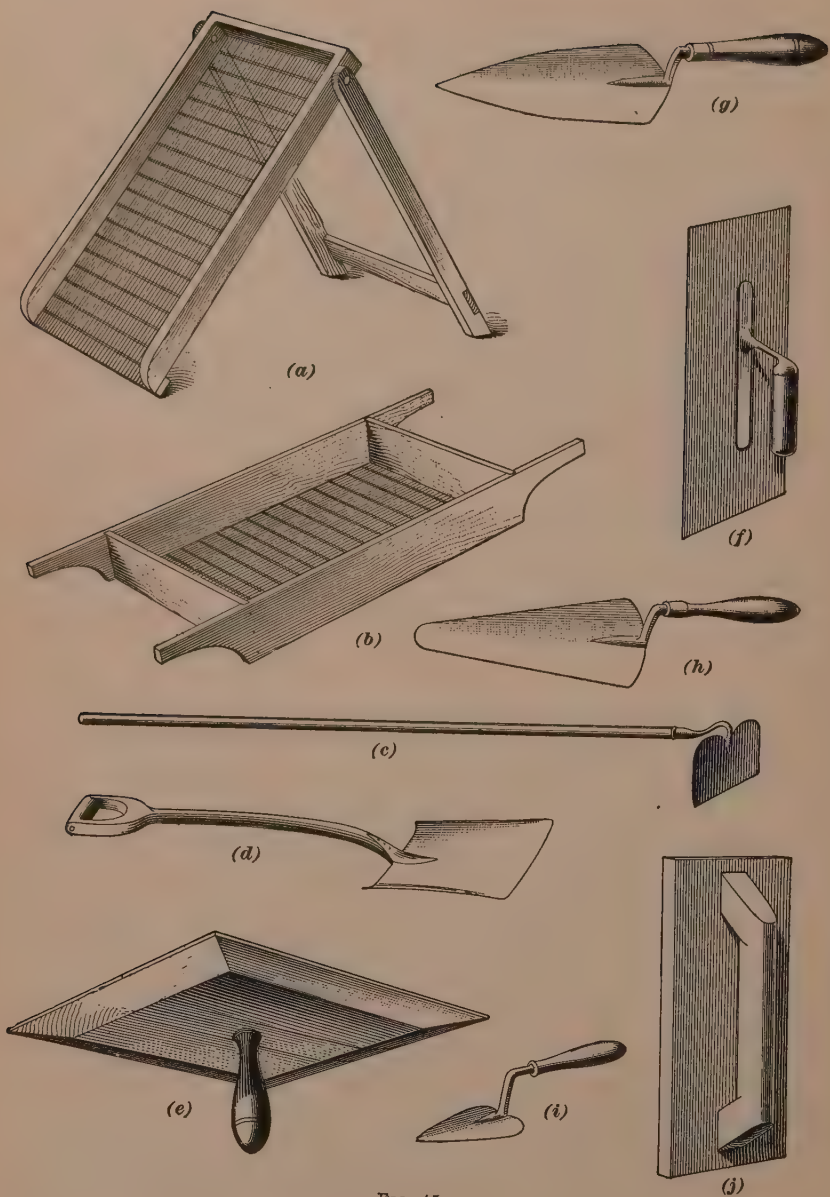


FIG. 45

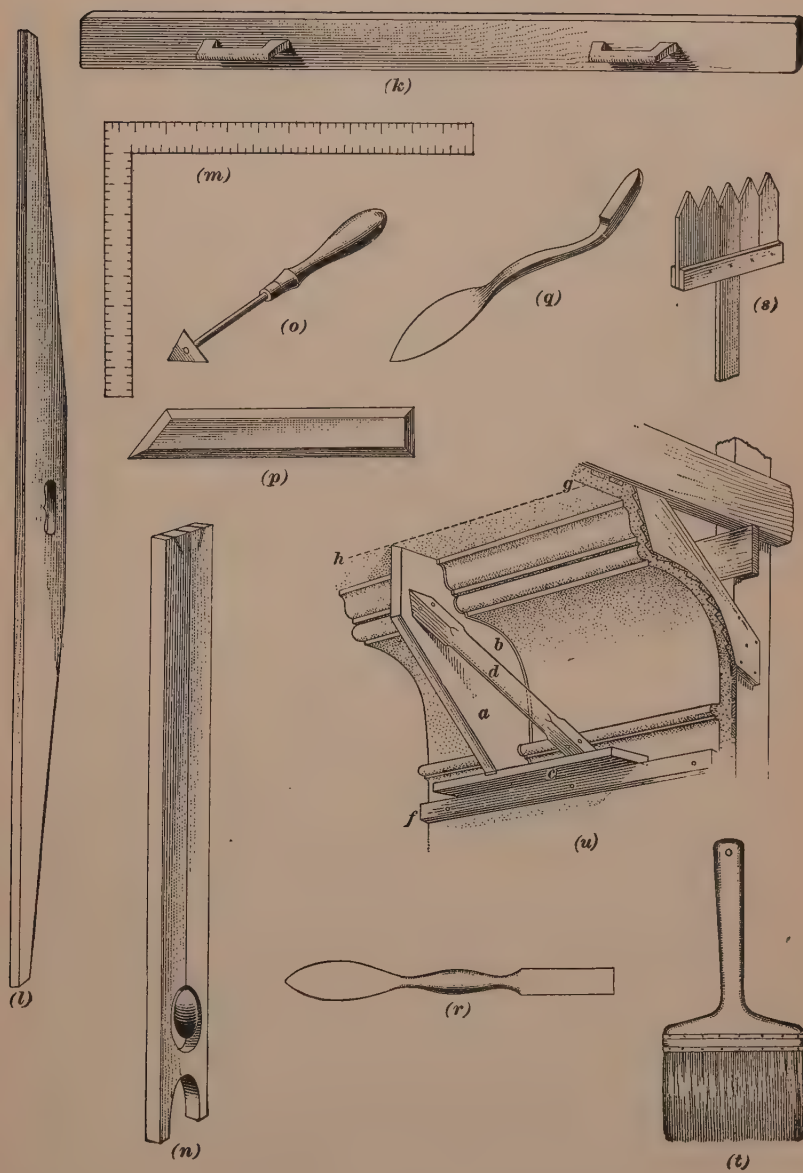


FIG. 45

57. The *plumb*, shown in (*n*), is used to determine whether or not the plastered surfaces are plumb by applying one of its straight sides to the surface. If the plumb-line, hanging freely, lies along a shallow groove cut in the face, parallel to the sides, the surfaces are true.

58. *Jointing and mitering tools*, shown in (*o*), (*p*), (*q*), and (*r*), are used for picking out and finishing angles and miters in moldings, etc.

59. The *comb*, shown in (*s*), is used for scratching the surfaces of the first and second coats of plaster, to form a good key for the ensuing coat. It consists merely of pieces of lath nailed together, and having one end sharpened, as shown.

60. *Brushes* of various kinds are used by the plasterer. That shown in (*t*) is used for dampening the surface of the plaster while it is being worked smooth.

61. *Templets* of various kinds are used for forming cornices and moldings. The templets are made of wood or sheet metal cut to the required outline, and are backed by wood. In (*u*) is shown one form of templet, which consists of a board *a*, to the beveled inner edge of which is attached a thin zinc or steel plate cut to the outline of the cornice, as at *b*. The strip *c* and the handle *d* brace the board *a* firmly and keep it square with the wall; *ef* represents a guide strip on which the strip *c* slides, and *gh*, a line drawn on the ceiling, flush with the outer edge of the board *a*, which is kept along this line. The frame of this templet, consisting of the pieces *a*, *c*, and *d*, is known sometimes as a *horse*. Templets are made either right-hand, as shown, to be pushed from right to left with the right hand, or left-hand, to be pushed from left to right with the left hand.

LIME PLASTER

62. Definition.—*Lime plaster* is a form of plaster the principal ingredient of which is lime. The lime is mixed with sand, hair, and water to form a plaster which is applied to the wall, or to the lathing. The finishing coat of plaster consists of lime, plaster of Paris, and sometimes marble dust.

63. Characteristics.—Lime plaster hardens gradually as the lime in the plaster absorbs carbon-dioxide gas from the air. Lime plaster requires considerable time to become thoroughly hardened. This, however, has certain advantages, as it gives the plasterer more time to true up his work, and the mortar can be retempered without destroying its efficiency. When properly made with good lime, lime plaster forms a serviceable wall, and is sometimes preferred to gypsum plasters.

64. Lime.—There are many kinds of lime on the market and care should be exercised in selecting the one to be used. Lime is generally slaked at the building, which requires time and space. It should be thoroughly slaked so that there will be no unslaked particles of lime in the plaster. If unslaked particles occur in the plaster they are apt to slake after the plaster has been placed on the wall and force pieces of plaster off the wall. This is known as *popping*, or *pitting*.

When the lime is slaked it is generally in the form of a paste, called *lime paste*.

65. Hydrated Lime.—In place of lump lime, hydrated lime may be used. Hydrated lime is lime that has been slaked by machinery. Hydrated lime is used extensively in the preparation of the first and second coats of lime plaster, and some especially prepared brands are used in the mixture for the finishing coats of plaster, and in ornamental work. Wherever lump lime can be used in the various plaster mixtures described in the succeeding articles, hydrated lime may be used, and the time and space required for slaking the lime can be saved.

66. Coarse Stuff.—Coarse stuff is used for the first coats of plaster, and is made by mixing the proper quantities of sand and well beaten hair with lime paste.

67. Fine Stuff.—Fine stuff is used in the preparation of the finishing coat of plaster. It consists of lime paste that has been diluted with water until it is as thin as cream. The substance is then allowed to settle. When the surplus water

appears clean and the lime held in suspension has settled, the water is drained off. The moisture in the mass is then allowed to evaporate until the paste becomes sufficiently stiff for use.

68. Plasterers' Putty.—Plasterers' putty, or lime putty, is practically fine stuff except that the creamy fluid has been strained through a fine sieve. This makes the paste much more velvety than fine stuff.

69. Gauged Stuff.—Gauged stuff for the finished coating of walls and ceilings consists of about three-fourths fine stuff or plasterers' putty, and about one-fourth plaster of Paris. The plaster of Paris causes the mixture to set quickly, and the mixture must be used immediately. No more should be prepared than can be applied in 20 or 30 minutes.

70. Hair and Fiber.—Hair and fiber are used in plaster for the reason that plaster does not possess sufficient cohesive power to bind it together firmly until it has hardened or set. Hair is used largely for this purpose. Cattle hides are the chief source from which plastering hair is obtained. After being cleansed of all grease, the hair is washed and dried, and packed into bags that hold a bushel, measured loose, and weigh from 6 to 8 pounds.

Manila fiber is probably the best, but it is somewhat expensive. Sisal, obtained from a species of cactus, is an excellent fiber and is frequently used. Cottonwood and coconut fiber are also used, although much bulkier than hair. Gypsum plasters usually contain either Manila, jute, wood, or asbestos fiber as a binding material.

71. Water.—Water used in the preparation of plaster should be clean and free from oil, acid, strong alkalis, or vegetable matter. Such substances affect the strength of the plaster as well as the rate of setting.

72. Sand.—Sand for plastering should be angular, of medium fineness, and clean, but above all it should be graded from fine to coarse in size of particles. Before using, all sand should be screened to remove the too coarse particles,

and, if wanted for use in the finishing coat of plaster, it should be passed through a fine sieve. The best plaster is made from screened, washed, and dried sand. White sand is used sometimes to give a firm, white surface to the finishing coat of plaster, and marble dust is used for the same purpose.

73. Quantities of Materials Required.—The scratch and brown coats of lime plaster together, when laid on wood lath having $\frac{3}{4}$ -inch grounds, will require about 600 pounds of lime, 3,600 pounds of sand, and 24 pounds of hair, or 16 pounds of hair and 8 pounds of fiber for 100 square yards of surface. Metal lath will require about 700 pounds of lime, 4,200 pounds of sand, and 28 pounds of hair for the two coats for the same area. The quantities given are approximate only, as lime and sand vary in different sections of the country.

GYPSUM PLASTER

74. Definition.—*Gypsum plaster* is a form of plaster, the principal ingredient of which is gypsum. It is a quick-setting, hard, plaster which is delivered at the building in a dry state and is made ready for use by the addition of water, or sand and water.

Gypsum plasters are also known as *cement plasters*, *patent plasters*, *prepared hard plasters*, and *hard wall plasters*.

75. Manufacture.—Gypsum plasters are made of gypsum rock which is found in many parts of the world. This rock is ground and calcined, or burned, and some of the water in its composition is driven off. The product is then mixed with a binder and a retarder. The binder consists of hair or fiber to give tenacity to the plaster while setting. The retarder is a material that is added to prevent the plaster from setting or getting hard too quickly. These materials are weighed and thoroughly mixed together by machinery, thus assuring a uniform product.

Gypsum plaster is put up in jute bags containing 100 and 125 lb., in paper bags containing 80 lb. and in barrels containing from 250 to 300 lb.

After the plaster has been used, the jute bags, if in good condition, can be returned to the manufacturer and a credit obtained for them.

76. Characteristics.—The product is uniform in quality and when mixed and applied according to the directions given by the manufacturers, produces dependable results. Gypsum plasters, like Portland cement, set quickly, whereas lime plastering hardens gradually by contact with the air. The quick setting of hard plasters permits the application of succeeding coats in a very short time, thus permitting a saving in time. Walls made of these plasters are very hard and strong compared with walls covered with lime plasters, and are fire resisting. In large buildings the dry materials may be distributed about the building, the adding of water and the mixing being done near the place where the plaster is to be applied.

77. Forms of Hard Plasters.—Gypsum plasters are made and sold in various forms, such as *neat*, or unsanded; *prepared*, or *sanded*; *wood fiber plasters*, and *bond plasters*.

Neat, or unsanded, plaster contains no sand and both sand and water must be added in the proper proportions to make it ready for use. When good sand is found in the neighborhood of the building that is being plastered, neat cement can be ordered to advantage and sand added at the building. This form of gypsum plaster is most generally used. Care should be taken not to add too much sand to the plaster as it is delivered in the package. The manufacturers usually stipulate the amount of sand that should be added.

Prepared, or sanded, plaster is neat plaster to which a proper amount of sand has been added by the manufacturer. Only water is added in preparing it for use. The manufacturer usually has facilities for obtaining sand of a suitable quality and can screen, wash, dry, and mix it with the plaster by machinery. In neighborhoods where good sand cannot be obtained, it is advisable to use the prepared plaster. The cost of sanded plaster is increased by the freight charges when it must be delivered a great distance from the factory.

Wood fiber plasters contain finely shredded wood fiber in place of the sand used in prepared plasters. The wood fiber gives to the plaster elasticity, toughness, lightness and strength. It also makes the plaster easier to apply. It is generally used without the addition of sand, but in some makes of wood-fiber plaster, sand may be added, using one part plaster to one part sand.

78. Bond Plaster.—Bond plasters, known as *concrete plasters*, are gypsum plasters manufactured especially for the first, or scratch, coat of plaster on concrete surfaces. These plasters adhere strongly to the relatively smooth surfaces to which ordinary plaster will not hold. They furnish bases to which the regular gypsum plaster will adhere. Bond plasters are sold neat or mixed with sand.

79. Plaster of Paris.—While not a wall plaster, plaster of Paris is used in connection with the finishing of plastered walls and is a gypsum product. It is used particularly in the finishing coat of walls and in ornamental plastering. It is mixed with a certain proportion of lime paste and sand, in forming cornices, moldings, and enrichments as well as for plain surfaces.

Plaster of Paris is unsuited for exterior work, as it is slightly soluble in water. It is mixed with lime paste and with finishing plaster to cause them to set more quickly.

80. Mixing Gypsum Plasters.—Plaster is mixed in a shallow box, one end of which is raised about 4 to 6 in., and the dry materials placed in the high end. Water is placed in the low end of the box, and the plaster hoed down into it, plaster being added until the mass is thoroughly mixed and of the proper consistency. When unsanded plaster is used, sand is added to the plaster and the whole mixed thoroughly while dry. Small quantities should be mixed with water at one time. No more should be mixed than can be used handily in about 1 hour.

81. Proportions.—For ordinary work with unsanded plaster, two parts of sand are mixed with one part of gypsum

for the scratch coat on wood or metal lath, or on plaster boards. Three parts of sand and one part of gypsum are mixed for the first coat on brick, tile, or gypsum blocks, and for the second coat on all walls.

APPLICATION OF LIME PLASTER

82. Names of Coats.—Lime and gypsum plasters are applied usually in three coats, the first being called the *scratch* coat; the second, the *brown, straightening, or floated*, coat; and the third, the *skim, white, or finishing*, coat. In some cases two coats only are used, the first coat being straightened and smoothed carefully to receive the finishing coat. On masonry, the separate scratch coat is usually omitted, but when applied is called the *rendering* coat. When combined with the brown coat on masonry, the first coat is called a *scratch-and-brown* coat.

83. Scratch Coat.—The method of applying the scratch coat of lime plaster to wood lath is illustrated in Fig. 44. The plaster, mixed to the proper degree of firmness in the mixing box, is carried to mortar boards, shown on the floor. A quantity of the plaster is placed on the wooden hand board, or hawk *b*, by means of the trowel *c*. The plasterer then takes small quantities of the mixed mortar on his trowel and spreads them firmly and evenly over the surface of the lathing. The plaster should hold together well, and yet be soft enough to be pressed in between the laths, so that it will bulge out behind the laths sufficiently to form a clinch or key. The thickness of the layer should be fully $\frac{1}{4}$ inch in front of the lath so that when it is set it will furnish a rigid surface upon which to apply the succeeding coats. After the first coat has somewhat hardened, it is scratched with comb-like blades *d*, in Fig. 44. From this operation, the first coat is called the scratch coat. The scratches or grooves form a key for the plaster of the next coat.

When a scratch coat is applied to a masonry wall, the plaster should be forced into all the joints and crevices, which serve the same purpose as the openings in the lathing.

84. Brown Coat.—The second, or brown, coat of lime plaster consists of coarse stuff to which a larger proportion of sand and somewhat less hair has been added than was used for the scratch coat. It should be about $\frac{1}{4}$ inch thick, and should be compacted firmly by rubbing with the float *g*, Fig. 46. Should the coat become dry during the process, it is moistened by applying water with the wide brush shown in *t*, Fig. 45.

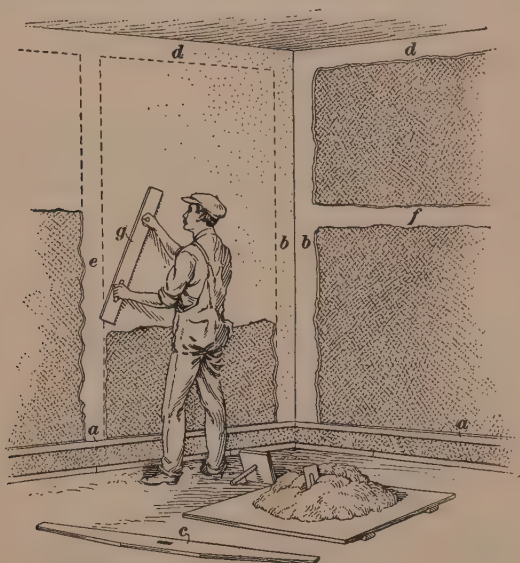


FIG. 46

On masonry walls, the brown coat is built out to the desired plane ready for the finishing coat, with as little rubbing as possible.

85. Green Work, or Laid-off Work.—Sometimes the brown coat is put on immediately after the scratch coat, without allowing time for the latter to dry out. This is known as *green work*, or *laid-off work*. In such cases, the first coat is made very rich in lime, while the brown coat contains a larger proportion of sand. The brown coat is worked into the scratch coat so as to form practically one coat.

Laid-off work is a less expensive form of three-coat work because of the fact that the same scaffolding can be used for the first two coats. The second, or brown, coat can be applied while the first, or scratch, coat is yet fresh.

86. Screeds.—In order to obtain true walls and ceilings, especially in large surfaces, where the grounds are far apart, the process known as *screeding* is employed. *Screeds* are plaster bands made of brown coat material formed on the scratch coat. They are 5 or 6 inches wide, and are shown at *b*, *d*, *e*, and *f* in Fig. 46. The screeds *b* are built up on the scratch coat at the angles, and are plumbed carefully from the grounds *a* by means of the straightedge *c*. They are kept back, however, about $\frac{1}{8}$ inch from the finished face of the grounds, to allow for the finishing coat. The horizontal screeds *d*, are formed at the ceiling angles. Intermediate vertical and horizontal screeds are also made as at *e* and *f*. Screeds are placed usually 4 to 8 feet apart, and form a true plane. The spaces between the screeds are filled in, flush with the screeds, and rubbed down with the two-handed float, or derby *g*.

Ceilings are treated in a manner similar to that used on the side walls, the screeds being leveled carefully.

When the scratch and brown coats are applied as one coat, as already mentioned, the screeds are built out before the panels are filled, the general method being the same as just described.

The space between the plaster grounds *a*, for the base-boards, and the floor, is finished, usually, only with a scratch and a brown coat of plaster.

87. Finishing Coat.—The finishing coat is the one that is visible, and it is made, generally, so as to give a pleasing finish to the wall, and to provide a good surface upon which to apply paint, papering, or other decorations. There are several kinds of finishing coats, known as *skim coat*, *sand finish*, and *hard-finished white coat*. In all cases the material is applied to the surface in the form of a stiff paste by means of the trowel *a*, shown in Fig. 47, and is spread uniformly over the surface of the brown coat to a thickness of about

$\frac{1}{8}$ inch, bringing the finished surface of the plastering out to the lines of the grounds. These finishes should be applied after the brown coat is dry.

88. Skim-coat finish consists of lime putty and very fine, white, sand. Usually, a little plaster of Paris is added to hasten the set and to form a harder surface. When the plaster is added, the sand is usually omitted. This mixture is polished to a glazed surface with a steel trowel *b*, the surface being kept moist by water applied with the brush *c*. For

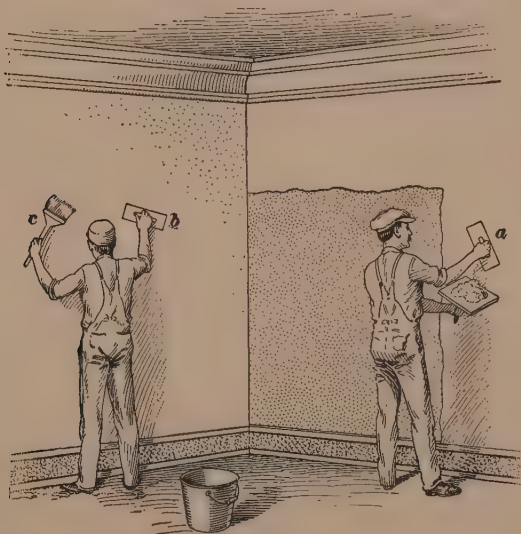


FIG. 47

100 square yards of surface, there will be required about 200 pounds of lump lime or 300 pounds of hydrated lime, 50 to 100 pounds of plaster of Paris, and 50 to 100 pounds of white sand.

89. Sand finish consists of gauged lime putty and sand, and is usually finished with a wood- or cork-faced trowel. Sand finishes may be fine or coarse as desired, the finish of the surface being determined by the sand that is used. This surface is sometimes obtained by covering the hand float *j*,

Fig. 45, with a piece of carpet, burlap, or felt, which will cause the sand to rise to the surface and present the characteristic sandpaper finish. About 200 pounds of lump lime, 50 to 100 pounds of plaster of Paris, and 400 to 500 pounds of sand, will be required for 100 square yards of surface.

90. Hard-finished white coat consists of 3 to 5 parts of lime putty gauged with 1 part of plaster of Paris, and to which marble dust or fine white sand has been added. This coating is smoothed and polished with the steel trowel. Marble dust gives a surface susceptible to a high polish. About 200 pounds of lump lime, 75 to 100 pounds of plaster of Paris, and 50 to 75 pounds of marble dust or sand will be required for 100 square yards of surface.

Sometimes the finishing coat is omitted in cheap work, the brown coat being brought to the line of the grounds and made as smooth as possible. This treatment saves the expense of applying the finishing coat of white plaster.

APPLICATION OF GYPSUM PLASTERS

91. The general processes used in applying lime plaster are also used in the application of gypsum plasters. Lime plaster hardens and dries somewhat slowly by contact with the air. It hardens by absorbing and combining with carbon dioxide in the air, and does not become thoroughly hardened for several months.

Gypsum plaster, on the other hand, sets in the same manner as Portland cement, and, although it may still be wet or moist, it may be thoroughly set and hard. The time required for gypsum plaster to set can be regulated by the addition of different substances. The manufacturers arrange the time of setting so that their product will set in a fixed time which will yield the best results. Hence, with gypsum plaster, the second, or brown, coat can be applied over the scratch coat within 2 or 3 hours after the first coat has been applied, even though the first coat is still wet. However, the first coat should be set and hard. The first coat should be scratched before the material has set.

If the first coat is allowed to stand until it is too dry, it should be sprinkled with water before applying the second coat.

The second, or brown, coat, also called the *float*ed coat and the *straightening coat*, is about $\frac{1}{4}$ inch thick. The same methods are used in screeding and straightening this coat as have just been described for lime plastering.

Solid partitions are formed by applying a scratch coat and a brown coat to the studding and lathing shown in Fig. 29. The plaster is brought out to within $\frac{1}{8}$ inch of the faces of the grounds, to allow for the finishing coat.

The finishing coats described for lime plastering may be applied to gypsum brown coats. Manufacturers supply ready-mixed finishes for use with their plasters. They also give directions for their proper use, and for finding the quantities of materials required.

KEENE'S CEMENT

92. Keene's cement is made by recalcining plaster of Paris which has been saturated with a solution of alum. When properly applied, the material becomes very hard and takes a high polish. Its hardness makes it a satisfactory material to use for finishing the lower portions of walls where the surface is liable to injury, as in kitchens and bathrooms. In such cases, the surfaces of the plaster are marked off with lines to imitate the joints of tile work.

93. Keene's cement is made in four grades, as follows: *Regular*, for general plastering purposes; *fine*, for wainscots, columns, extra white finish, and for backing artificial marble; *superfine*, for facing artificial marble; and *quickset*, for castings and moldings. The regular grade is commonly used for plastering the plane surfaces which occur in ordinary work.

94. Application.—Keene's cement may be applied on brick, stone, concrete, hollow tile, or gypsum blocks, or to wood or metal lath. The general methods and the tools used for lime or gypsum plastering are employed in applying Keene's cement plaster.

The first, or scratch, coat of Keene's cement plaster is mixed in the proportions of 1 cubic foot of Keene's cement, 1 cubic foot of dry hydrated lime, 5 cubic feet of sand, and about $\frac{3}{4}$ bushel of hair. The first coat should be well scratched and allowed to harden before the second is applied.

The proportions for the second, or brown, coat are: 1 part of Keene's cement, 1 part dry hydrated lime, and 7 parts sand. This coat should be allowed to dry before the final, or finishing, coat is applied.

95. Finishes.—The finishing coat of Keene's cement may be one of three, known as *smooth* finish, *sand-float* finish, and *smooth-hard* finish. Any one of these three may be applied to gypsum plaster or lime plaster brown coats, to a Portland cement base, or to the second coat of Keene's cement.

To secure the smooth finish, the finishing coat is composed of 4 parts Keene's cement, to which is added 1 part of dry hydrated lime. When nearly set, the coat is troweled to a smooth polished surface.

The sand-float finish is obtained by mixing 1 part of Keene's cement with 1 part of dry hydrated lime, and not more than 7 parts sand. The surface is brought to the desired finish with a wood or cork float. The texture and color of the sand used will appear in the finished surface.

For the smooth hard finish, Keene's cement is used neat, that is, without the addition of either lime or sand. The finish coat is troweled to the desired finish.

All the above are mixed with suitable quantities of clean water.

PORTLAND CEMENT PLASTER

96. Portland cement plaster is used mainly on account of its hardness, and for its fireproofing and water proofing qualities. This plaster requires only a few hours to set, and in setting it combines with the water used in mixing. One or two days' interval between the application of the coats is all that is required.

97. Materials.—The materials used in making Portland cement plaster are Portland cement, sand, hydrated lime, and water. In some cases a special waterproofing material is added. The hydrated lime has a waterproofing value, and it is used also to give the mixture smoother working qualities.

98. Proportions.—The usual proportions for Portland cement plaster are 1 part Portland cement $\frac{1}{10}$ part hydrated lime, and $2\frac{1}{2}$ parts sand.

99. Application.—Portland cement plaster is applied usually in two or three coats, each coat being applied in thin layers and built up to the full thickness. No more plaster should be mixed than can be applied in 20 or 30 minutes, as the plaster should not be applied after it has begun to set. Each coat should be scratched and allowed to set, but not to dry, before the next coat is applied.

100. Finishes.—Either of two finishes, known as *smooth-troweled* and *stippled*, may be given to the final coat of Portland cement plaster.

The smooth-troweled finish is secured by allowing the cement to harden partly, but not to acquire its initial set. The surface is then troweled smooth with as little rubbing as possible. Too much rubbing is apt to bring the water and cement to the surface, resulting in an unsatisfactory finish.

A stippled finish may be given the surface by first troweling as is done for a smooth-troweled finish. While the surface is still moist, it is patted lightly with the end of a brush of broom straw.

CAEN STONE CEMENT

101. Natural Caen stone, found in France, possesses a texture and color that is very pleasing and satisfactory for interior decoration. It is crushed and mixed with special cements and chemicals and applied in the form of plaster to the interior surfaces of walls. It is generally used to imitate the stone from which it is made. After it has been applied to walls, imitation joints are cut in the surface and are filled with Keene's cement. This treatment results in a fine creamy

limestone effect that is extremely attractive. Moldings are run in the same manner as is done with plaster. The surface is sometimes scratched to represent 8- or 10-cut limestone work, or it may have a rubbed finish. The Caen stone cement is applied over a base of Keene's cement plaster and is about $\frac{1}{4}$ inch thick. It is brought to a true surface in the same manner as standard plaster. After the joints have been finished, the whole surface is rubbed smooth with sandpaper. The work of applying and finishing Caen stone requires high-class workmanship and experience.

ORNAMENTAL PLASTERING

MATERIALS AND PREPARATION

102. Definition.—As already defined, ornamental plastering is the art of forming ornament in plaster on plain surfaces. This ornament is in the form of moldings, cornices, paneling, pilasters, and other architectural and decorative features which add to the interior of a building.

103. Materials.—The principal materials used for ornamental plaster work are plaster of Paris, lime paste, and some of the finer kinds of gypsum plasters. The tools used for forming the ornament have already been described.

104. Cornices and moldings are run by the plasterer as will be described later. Ornaments, columns, pilasters, and sometimes moldings are cast at the shop and brought to the building ready to be set in place. Other ornaments are manufactured and kept in stock and are ordered from catalogs or samples. These also are brought to the building and set in place by the plasterer.

105. Preparation for Moldings and Cornices.—Cornices and moldings are made, or run, in place, usually before the finishing coat is applied. Where the extreme projection of the molding or cornice is less than 2 inches from the finished wall, or ceiling, the core is formed of coarse stuff, or of brown

coat. The finished surface of the cornice is formed by running a thin coating of finishing material over this core.

106. When the projection of the cornice is several inches, a base of wood blocking is formed to which lath is attached, and this base is coated with the scratch and brown coats. This rough plastering is brought within $\frac{1}{4}$ inch of the finished surface and upon this base the finishing coat is run so as to produce the desired cornice.

107. In Fig. 48 is shown a cornice of small projection, which is run against the brown coat of the wall *a* and ceiling *b*. A core *c* is run with a muffled templet, described later, and

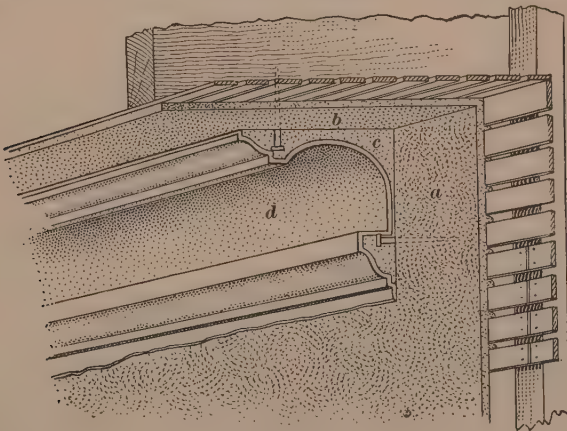


FIG. 48

may be made of coarse stuff or of a mixture of plaster of Paris and lime paste of which the finished cornice is to be made. If coarse stuff is used, it will be gauged, or mixed with plaster of Paris, so as to set rapidly. When this core is set, the cornice *d* will be run in finishing plaster and plaster of Paris and will form a true, clean, cornice.

108. The cornice in Fig. 49 can be run directly on the brown coat *a*, the thicker part *b* being formed of the finishing plaster of which the cornice is made. The picture molding *c* is placed so that it forms part of the cornice.

109 In Fig. 50, the base of the cornice is formed by nailing a strip of metal lath in the angle of the wall and ceiling

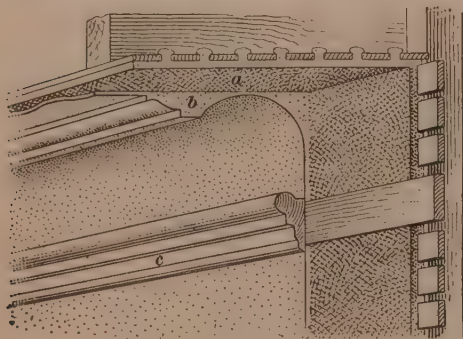


FIG. 49

so as to form a core. This lathing is applied before the plastering is started and is plastered with the first two coats when the remainder of the wall is plastered. The strip *a* is nailed on the ceilings to form a base for the projection *b* of the cornice.

The cornice is shown in section at *c* and is run directly on the brown coat *d*. At *e* and *f* are shown the guides that are used in directing the movement of the templet used in forming the cornice.

110. In Fig. 51 is shown a cornice with a considerable projection. It is *blocked out* with blocks *a* nailed to each joist above, or about 16 inches on centers. To this blocking the lathing is nailed and the entire lathed surface is coated with scratch and brown coat as shown at *b*. Upon this surface the finished cornice *c* is run.

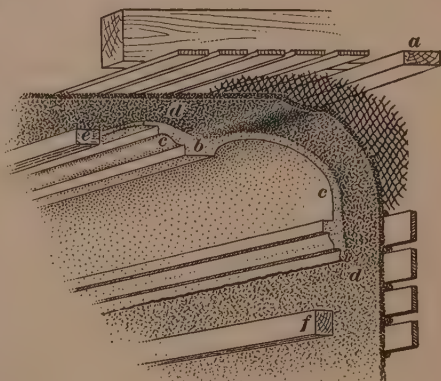


FIG. 50

111. Preparation for Curved Ceilings.

Curved ceilings often require an intricate framing of light iron or steel in order to support properly the metal lath on

which the plaster and ornamental work is applied. Fig. 52 shows the furring necessary to form the large sweep of the

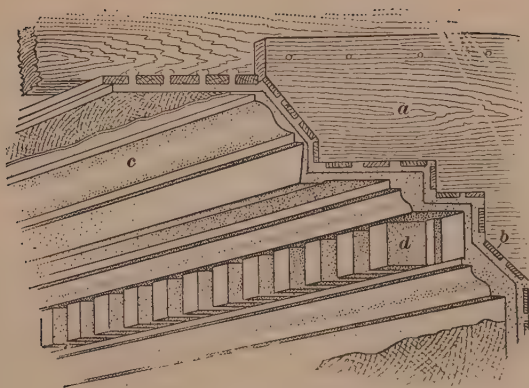


FIG. 51

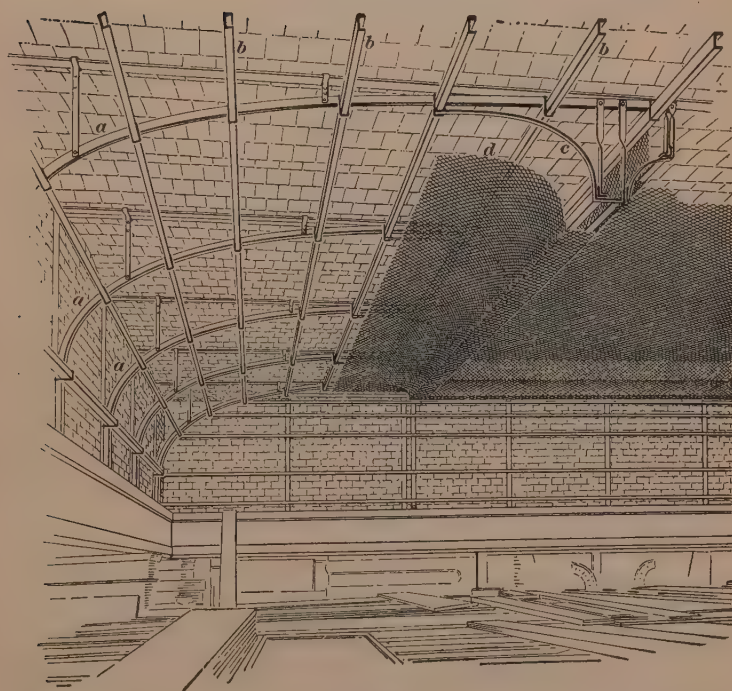


FIG. 52

coved ceiling and the ornamental cornices and beams. The curved bars *a* support the channels *b* and *c*, to which the metal lath *d* is attached. When this lathing is all applied, the plastering is carried on in the usual manner. In a ceiling such as the one shown, considerable ornamental plaster-work would be supported on the wire lath.

112. Curved surfaces may be formed in ribbed-metal lath when the construction requires a stiffer surface than will be furnished by the plain lath alone.

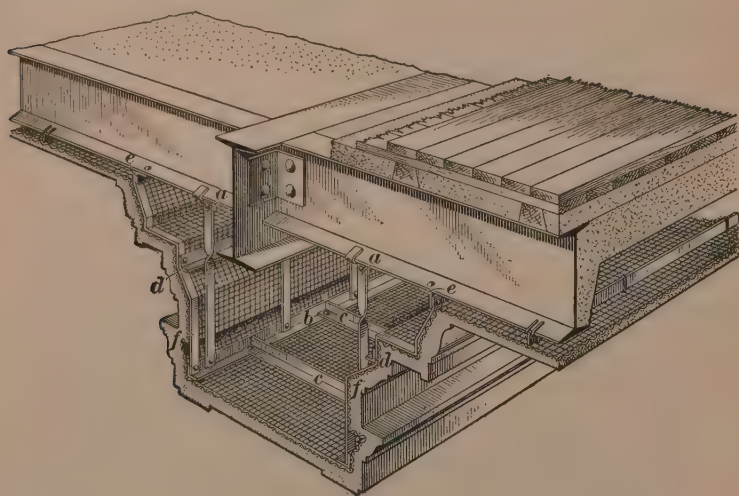


FIG. 53

113. Preparation for False Beams.—An elaborate beam construction is shown in Fig. 53. This is typical of work in fireproof buildings, where the use of wood must be reduced to a minimum. In this construction the hangers *a* are connected to horizontal angle bars *b*. This angle and a similar one on the other side of the beam are connected and braced by means of the cross-piece *c*. Other angle bars are shown at *d* and *e*. At *f* are shown flat bars that are formed to the approximate outline of the cornice, and which are supported by the horizontal angles. The angle bars *e* are

attached directly to the structural beams of the ceiling. This entire construction is enclosed by wire lath to which the ornamental plastering, as shown, is attached.

APPLICATION OF THE PLASTER

114. Running Cornices.—Upon bases formed as just described, plaster cornices are run. Cornices are run before the finishing coat is put on. Longitudinal strips are attached to the wall, as shown at *e* and *f* in Fig. 50, or at *b*, Fig. 54, on which a templet *a* is run. Sometimes a strip is attached also to the ceiling, but more often the ceiling guide is merely a line.

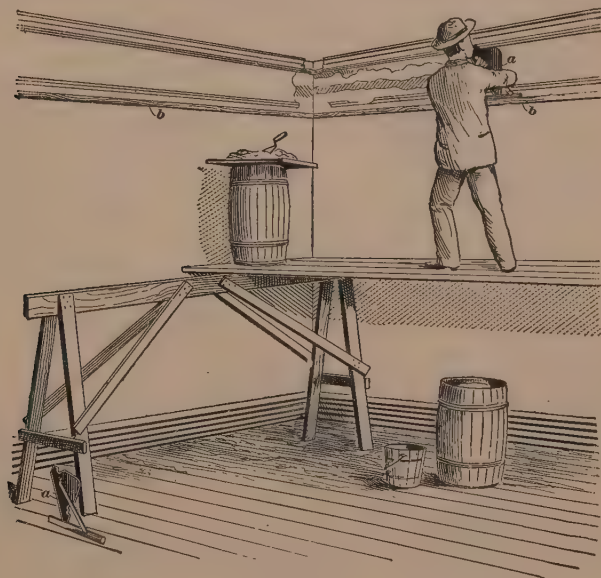


FIG. 54

If coarse stuff is required, it is made to conform to the approximate profile with a muffled templet, that is, by forming a layer of plaster of Paris about $\frac{1}{8}$ inch in thickness along the edge of the templet; or an extended profile can be cut out of zinc and attached temporarily to the correct templet. The templet is placed in position and is pushed along the angle of

the wall. When the coarse stuff has had time to dry, the surface is coated with gauged stuff and worked over carefully with the correct templet until an exact and perfect finish is obtained.

115. Corners and intersections, which cannot be run on the wall, are molded and mitered by hand on the wall, using the tools shown at *o*, *p*, *q*, and *r* in Fig. 45. The plasterer extends the surfaces until they meet at a neat angle. Another way in which the cornice is formed is to run sections of the cornice on a bench, and attach them to the wall by means of a thin mixture of plaster of Paris and water. The internal and external miters are cut on certain sections and set in place.

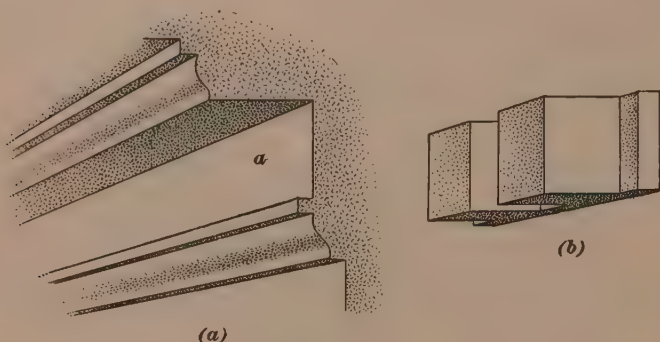


FIG. 55

The joints are then touched up by the plasterer. When this method is followed, the corner is put up first, and the remaining cornice is run to it.

A cornice such as shown in Fig. 51 cannot be run complete on account of the dentil course shown at *d*. The cornice is run without the dentils and the dentils must be cast separately and placed in a recess as shown at *a*, Fig. 55 (a). The dentils are cast in lengths (b), and stuck in place by means of thin plaster of Paris.

116. Centerpieces.—Circular centerpieces consisting of plain moldings are formed in the same manner as run cornices, except that the mold, or templet, is so fastened as to swing around the center of the ornament. Decorated centerpieces

are usually cast in a mold and are stuck on the ceiling with thin liquid plaster of Paris.

117. Ornamental Ceilings.—Nearly all kinds of ornamental plastering on ceilings, such as moldings, bas-relief, imitations of foliage, etc., may be formed of plaster of Paris. In paneled ceilings, the ceiling is first marked to show the location of the moldings which are to form the design. The moldings are then cast, or run, and cut by a saw into the required lengths with mitered ends for the points of intersection. All the intersections should be carefully pointed with plaster of Paris, and smoothed with a tool to secure perfect joints in all parts of the work.

In Fig. 56 is shown a portion of an ornamental plaster ceiling in which the design is made up mainly of molded members and leaf-like finials. Very shallow and delicate forms of cast-plaster ornaments are made by pouring the plaster of Paris into a mold, and while the plaster is still soft, pressing a canvas backing into it. This canvas with the plaster ornamentation attached is then applied to the plastered surface, joints being formed at such places as can be easily pointed and concealed.

The liquid plaster which is used to attach cast-plaster ornaments to the ceiling is usually a sufficient fastening for small moldings and ornaments. For large moldings and ornaments, however, it is customary to apply wooden grounds to the ceiling framing before the plastering is done, and the plaster moldings are nailed to these grounds.

118. Applied Ornamentation.—A great variety of plaster ornaments, such as corbels, brackets, sculptured panels, ceiling ornaments, friezes, bands, rosettes, and center-pieces, may be obtained from companies making a specialty of such work. For some designs, these ornaments may be made of plaster of Paris, while in other designs the material may be of a special composition made of ground chalk, paper pulp, wood fiber, glue, and other substances. Ornaments of this composition are tougher and lighter than those cast in plaster, and they can be obtained in sizes and shapes which



Fig. 56



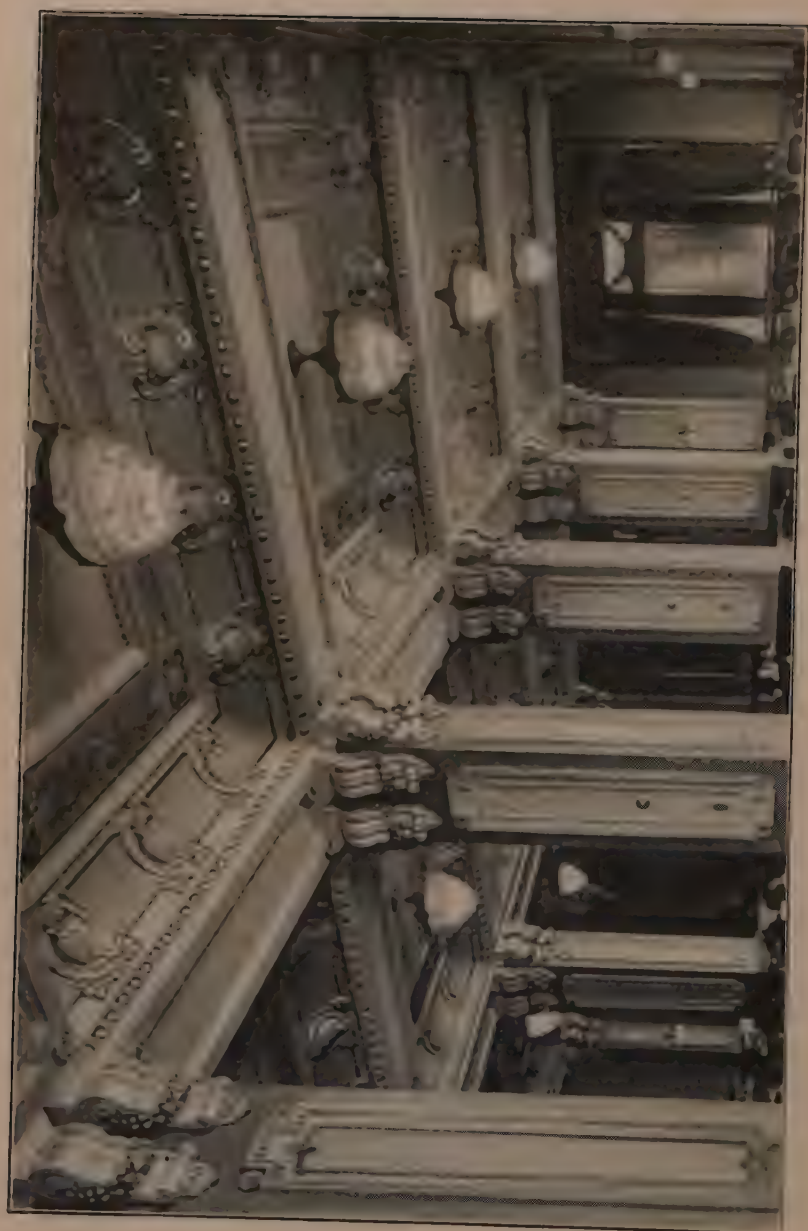


FIG. 58

can be built into practically any design. Fig. 57 shows a number of such ornaments as they are furnished by the manufacturer. The size is marked beside each.

119. In Fig. 58 is shown the application of ornamental plastering to a dining-room in a modern hotel. In this work the piers were plastered square on gypsum blocks, while the beams were plastered on metal lath furred out to the required shape. The ornamentation, in the form of panels, rosettes, consoles, moldings, and cartouches were fixed in place with plaster of Paris. This figure illustrates the use of ornamental plastering to represent solid architectural forms, such as columns, piers, brackets, etc. Elaborate architectural effects can thus be produced by the use of ornamental plaster, at a smaller cost than if made of stone or expensive hard woods.

EXTERIOR PLASTERING

STUCCO

KINDS AND ADVANTAGES

120. General.—As has been stated, the term *stucco* is applied to plaster used on the exterior surfaces of walls. Stucco should be composed of materials that will stand exposure to heat, cold, and water, and thus form a durable outer covering for the building.

121. Three kinds of stucco are distinguished by the different materials that enter into their composition. *Lime stucco* consists principally of lime, sand, and aggregates. *Portland cement stucco* consists of Portland cement, sand, lime, and aggregates. *Magnesite stucco* consists of magnesium carbonate, or magnesite, mixed with a liquid chemical, and when applied to wall it forms a hard, weather-proof stucco.

122. Advantages of Stucco.—Stucco can be applied upon masonry walls and wooden walls in the same manner as



FIG. 59

interior plastering. It is strong, weatherproof, and fire-resisting to a large degree. The surfaces can be treated to imitate solid stone masonry and permit the execution of architectural effects which, if obtained by the use of stone, would be very expensive. Stucco can be finished as a plain coating or in tints and surface textures as desired.

The walls of an entire building may be coated, or the stucco may be applied to portions of the wall while other parts may be of brick, stone, or wood, as shown in Fig. 59. A stucco coating can be applied to old wooden or masonry buildings, renovating the building and greatly improving its appearance.

PREPARATORY WORK FOR STUCCO

123. General Requirements.—Before any stucco is applied all roof gutters should be set, and conductors, hangers, and all other fixed supports and fasteners should be in place, so that there will be no break made in the surface of the stucco after it is once completed. All of the outside finished trim should be placed at the correct distance from the studding, or furring, to show its proper projection in relation to the finished surface of the stucco. Wall copings, balustrade rails, chimney caps, cornices, and similar work, whether made

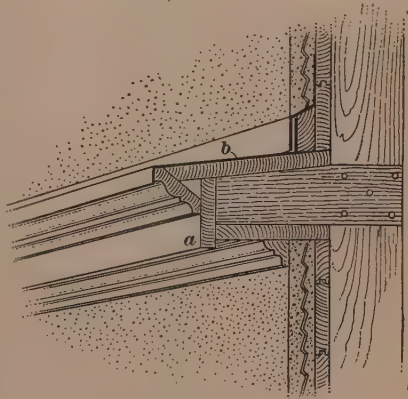


FIG. 60

of wood, stone, or stucco, should be designed with ample drips, grooves, or lips, as at *a* in Fig. 60, or at *a* in Fig. 61, to keep water from running down on the face of the stucco.

124. Flashings.—Suitable flashings should be provided over all door and window openings, or wherever any projecting wood trim occurs, as at *b* in Fig. 60, and at *a* in Fig. 62, to

prevent water from entering the joints between the wood and the stucco. With copings of stone, cast cement, or brick, with mortar joints, continuous flashing should extend across the wall under the coping, and should project beyond to form an inconspicuous lip over the edge of the stucco. Similar continuous flashing should be so installed as to insure absolute protection against leakage back of the stucco.

Special attention should be given to the design of gutters and conductors at the returns of porch roofs, where it is possible that an overflow would produce unsightly discolorations of the stucco. At the intersections of sloping roof with

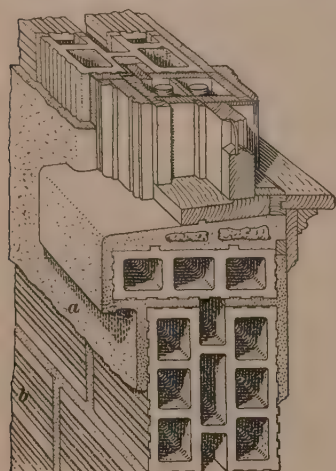


FIG. 61

stuccoed wall surfaces, the roof courses should first be flashed separately, and an additional strip of flashing placed over the roof flashing, extending 4 inches up on the wall surface. The stucco surface should then extend down to within 2 inches of the roof surface. Care should be taken to see that the water is in all cases led away from the stucco surfaces.

125. New Masonry Surfaces.—

New surfaces of stone, brick, hollow building-tile, or concrete, should have ample roughness to assure a strong bond and key between the stucco and the surface. When the walls are of brick, the joints should be not less than $\frac{1}{4}$ inch thick. The joints in new walls must be left rough, and not struck smooth. Hollow building-tile used for walls usually are scored, or grooved, to furnish a key for the stucco, as shown at *b* in Fig. 61.

126. Existing Masonry Surfaces.—When a masonry wall that is to be stuccoed has been in place for some time, as in the case of old buildings, the exposed surfaces should have all dirt, dust, or other foreign matter removed by

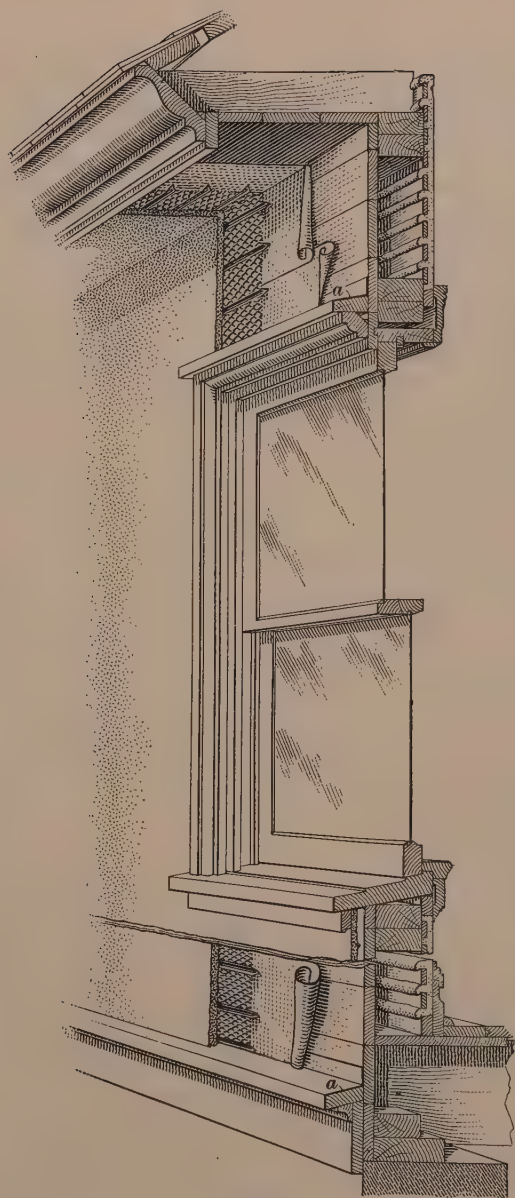


FIG. 62

means of a wire brush, or broom. All traces of moss or other vegetable growth must be removed, so as to present a clean, absorptive, surface. All loose, friable, or soft, mortar should be removed from the joints, to a depth of not less than $\frac{1}{2}$ inch. In case the surface has been painted, it will be necessary to remove the paint by means of a lye solution, or by a sharp tool which will hack away the surface. When the surface cannot be brought to such a condition that stucco will adhere firmly, furring and lathing must be applied.

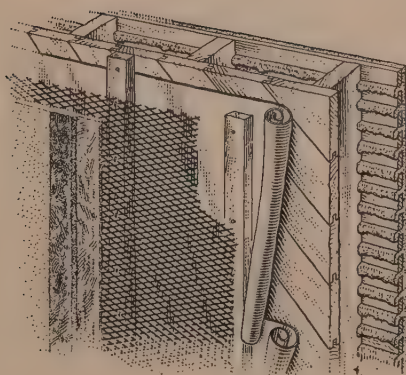
127. Furring on Masonry Walls.—When it is necessary to furr existing walls for stucco, wood or metal furring-strips should be placed vertically at 12 inch centers. Wooden plugs may be driven into the joints of the wall, to which the furring is nailed. When the furring forms part of the lath to be used, separate furring is unnecessary.

128. Sheathed Surfaces.—The frame of a wooden building should be rigidly constructed and well braced, so as to prevent cracking of the stucco from vibration, such as would occur during a violent windstorm. At least one course of horizontal bridging, or bracing, should be placed between the studs in each story height.

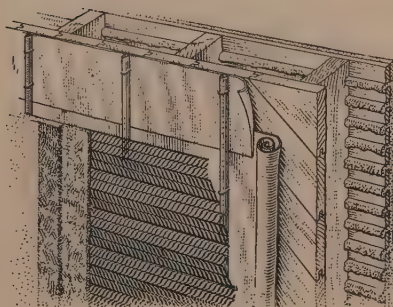
Sheathing boards should be not less than 6 inches nor more than 8 inches wide, dressed on both sides to a uniform thickness and nailed to each stud. Sheathing boards placed diagonally on the studding have been assumed to add greatly to the strength and rigidity of the building. Sheathing boards, however, laid horizontally across the wall studs, and fastened with at least two eight-penny nails at each stud, have been shown by tests at the United States Bureau of Standards, to produce satisfactory results with respect to the stucco itself.

129. Sheathing Paper.—Sheathing paper should be laid over the sheathing boards in horizontal layers, beginning at the bottom. Each strip should lap over the one below at least 2 inches.

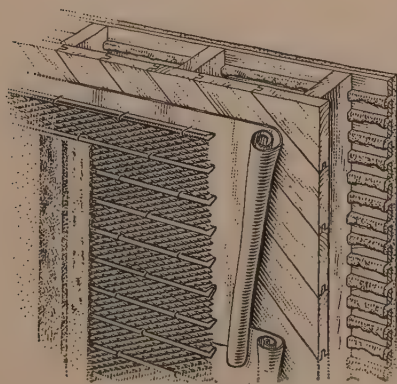
130. Application of Wooden Lath Over Sheathing. When stucco is to be applied to a frame building, the studs



(a)



(b)



(c)

FIG. 63

are sheathed and papered as just described. Over the paper, furring strips should be nailed about 12 inches on centers. The furring strips are placed vertically and the lath applied horizontally as for interior plastering. The lath should be separated sufficiently to provide a good key, and the joints broken as in interior lathing. Strips of metal lath should be bent around the corners and openings, which will tend to prevent cracks that might occur at these positions.

131. Application of Metal Lath Over Sheathing.—Metal lath may be applied over sheathing in any of three ways. The first is upon wood furring placed vertically 12 inches on centers and nailed securely to the sheathing, as in Fig. 63 (a). The second is upon metal furring as in (b), applied to the sheathing with staples. A third way is to use a combined lath and furring as in (c). The ribs should be stapled to the sheathing so that there will be a space for a key back of the lath.

132. Plaster boards are sometimes used as a base for stucco. They are applied directly over the sheathing, to which they are nailed. The paper is omitted in this case. A type of board should be used to which the stucco will adhere readily and which will not deteriorate under the weather. The usual size of such boards is 32 by 36 inches. Twelve broad-headed nails should be used for each sheet of this size. The vertical joints should be broken in every course.

MATERIALS FOR STUCCO MORTAR

133. Essential Materials.—The basic material comprising stucco may be either lime, Portland cement, or magnesite cement. What is known as *lime stucco* may or may not have a small amount of Portland cement added to it, and what is known as Portland cement stucco may or may not have a small amount of lime added to it. Magnesite cement cannot be mixed with either lime or Portland cement. The other ingredients, in the case of either lime stucco or Portland cement stucco, are fine aggregate, water, colored aggregate, mortar colors, and hair, or fiber, for the purpose of improving the quality of the stucco, or giving it a more pleasing texture or color. To vary the finish, colored aggregates may be added to magnesite stucco.

134. Portland Cement.—Any standard brand of Portland cement may be used for stucco. If a gray, or mouse-colored, stucco is desired, the ordinary gray Portland cement is used. If, however, a white stucco is desired, white Portland cements that are in the market can be used with white sand or marble dust.

If cement is used to harden lime in stucco, the amount of cement used should be about 20 per cent. of the amount of lime in weight.

135. Fine Aggregate.—Fine aggregate for stucco may consist of sand, or screenings from crushed stone or gravel. It should be well graded from fine to coarse particles, passing through, when dry, a screen having eight meshes to the linear



FIG. 64



I L T 31F—2019 FIG. 65

inch. Fine aggregate should not contain organic matter, nor more than 7 per cent., by volume, of clay or loam.

136. Water.—The water used for stucco should be clean and free from oil, acid, strong alkalis, or vegetable matter, as such substances affect the strength of the stucco, as well as the rate of setting.

137. Lime.—Freshly burned quicklime may be used for lime stucco. The lime must be slaked properly, and, preferably, should be run through a fine sieve in order to remove any unslaked particles. Hydrated lime also may be used for lime stucco, and should be used whenever a good quality of freshly burned quicklime cannot be obtained.

138. Hydrated Lime.—For the purpose of making cement stucco more waterproof, a small amount of hydrated lime may be added to Portland cement stucco. This material gives the stucco a lighter color when it is used in the finishing coat, and causes the stucco to work smoother. The volume of the hydrated lime should not exceed 20 per cent. of the volume of the Portland cement used in the mixture.

139. Colored Aggregates.—The principal materials used for giving the finishing coat of stucco a more pleasing color or texture are sand, colored pebbles, crushed granite, marble, sandstone, quartz, and gravel. These materials occur in a variety of pleasing colors, and a mixture of two or more of them is used to give a variegated appearance, as indicated in Figs. 64 and 65.

140. Mortar Colors.—Commercial preparations for coloring stucco mortar may be mixed in the finishing coat of stucco to give practically any desired color, or tone. These preparations are known as *pigments*, or *mortar colors*. As there is a possibility of reducing the quality of the stucco by the addition of too much coloring matter, the best authorities limit the amount to not more than 10 per cent. of the weight of the basis material. Only mineral colors should be used, and preference should be given to strong colors, of which

only small quantities need be used, rather than to the weaker colors, of which a larger amount is required to give the desired tone.

141. Hair or Fiber.—Hair or fiber is sometimes added to the first coat of stucco on wood or metal lath to assist in holding the stucco together until it has set. It is not necessary when the stucco is applied to masonry surfaces.

PREPARATION OF STUCCO MORTAR

142. Measuring.—The materials used for stucco mortar should be carefully measured, in order that uniform proportions may be secured. Uniformity in proportions is necessary for uniformity of quality and appearance in the finished stucco. This is particularly true when mortar colors are used for tinted effects.

A sack of Portland cement contains 94 pounds, and is assumed to occupy 1 cubic foot of space, while 1 cubic foot of hydrated lime weighs 40 pounds. The weight of a cubic foot of sand will vary from 80 to 120 pounds, according to whether it is fine, or coarse, or well graded. Lime paste is measured by the cubic foot, after being thoroughly slaked.

PROPORTIONS OF MATERIALS

143. Lime Stucco.—It is considered desirable with lime stucco to have the scratch coat the richest, and each succeeding coat leaner. An average of the quantities to use, based on hydrated lime, would be 10 cubic feet of lime to 27 cubic feet of sand for the scratch coat on masonry, 11 to 27 for the scratch coat on wood lath, and 12 to 27 for the scratch coat on metal lath. For second coats, 1 cubic foot less of lime should be used on each 27 cubic feet of sand. Where cement is to be used for accelerating the hardening, 1 cubic foot makes a good quantity to add to each of the above measurements.

144. Cement Stucco.—Each of the coats of Portland cement stucco should be mixed in the proportions of about

1 part, by volume, of Portland cement to 3 parts of sand, or fine aggregate, the exact proportion depending upon the nature of the sand, and whether two-coat, or three-coat work is being applied. It is well to increase the amount of the sand by about $\frac{1}{2}$ part for each successive coat. Hydrated lime may be added to the mixture, but not to exceed 20 per cent., by volume, of the cement. The proportions of the finishing coat will vary somewhat when special finishes are desired. When mortar colors or special waterproofing compounds are added, it is usually advisable to omit the hydrated lime.

MIXING

145. Lime Stucco.—The ingredients of the mortar should be mixed with the minimum amount of water to obtain the required consistency. When cement is added, the mixing should continue until the lime and the cement are evenly distributed, and the mass is uniform in color.

146. Cement Stucco.—The ingredients of the cement stucco should be mixed dry until a uniform color is obtained. Sufficient water should be added to produce, after thorough mixing, a mortar that is sufficiently plastic to spread evenly under the trowel, and yet be stiff enough to hold its keys on the wall or to bond to the under coats.

Mixing by machine is desirable on all work and particularly on large jobs. A batch mixer should be used, and the mixing continued for at least two minutes after all the materials, including water, are in the mixer drum. No fresh material should be introduced into the mixer until all the preceding batch has been discharged. When hand mixing is employed, the mixing should be done in a watertight box, and sufficient turnings should be given the materials, both when dry and when wet, to secure uniform color and consistency.

147. Retempering.—Mortar that has partially hardened should not be retempered, that is, remixed with additional dry materials or water. If this is done, the strength of the stucco will be greatly impaired, the color will vary from that

of the rest of the work, and the stucco is apt to be soft and porous.

No more Portland cement stucco should be mixed at one time than can be used within 1 hour after water has been added to the dry materials. With lime stucco the time may be extended, if no cement has been added. Any mortar which has begun to harden should be discarded.

APPLYING THE STUCCO

148. Spraying.—Immediately before applying the first coat of stucco, the base, if of brick or porous masonry, should be sprayed, or wet down, but not completely saturated with water. This is more necessary in hot weather than on cool, damp days. This prevents too much water from being taken away from the lime stucco, and also prevents cement stucco from setting too quickly. The masonry surface should, however, absorb a small amount of moisture from the stucco, which is the reason that the background should not be saturated.

Wood lath should be sprayed, but not thoroughly soaked, just before applying lime stucco. Before applying cement stucco the lath should be thoroughly wetted. Metal lath, stucco boards, sheathing lath, and similar preparations need no spraying before applying the stucco.

149. Names of Coats.—Stucco usually is applied in three coats on wood, or metal, lath, and in two coats on masonry backgrounds. The finish will often constitute a separate application which is not usually considered as a coat. The first is known as a *scratch coat*, or when applied to masonry, as the *rendering coat*. The second is known as the *intermediate*, or *brown coat*. In two-coat work this coat may also become the finishing coat if it is only floated and not given any of the surfaces later described. The third coat, when applied, is known as the *finishing*, or *final*, *coat*.

150. Without allowing the plaster to dry out on the edge, the application of the stucco should be carried on continuously

in one general direction. This applies particularly to the quick-setting stuccos. When it is impossible to work the full width of the wall at one time, the joint should be at some natural division of the surface, such as a door or window, at a belt course, or behind a rain conductor.

151. Scratch Coat.—The first, or scratch, coat of stucco should cover the base on which it is applied, and should be troweled well to insure a good bond with the base. On masonry walls, this coat should be sufficiently thick to fill all crevices, and cover the wall with a thickness of at least $\frac{1}{4}$ inch. On wood lath, the minimum thickness of the plaster over the lath should be $\frac{3}{8}$ inch, while on metal lath, a thickness of $\frac{1}{4}$ inch is sufficient. Before the scratch coat has set, it should be heavily cross-scratched with a saw-toothed metal comb, or other suitable device, to furnish a good mechanical key for the intermediate coat.

152. Intermediate Coat.—The intermediate, or brown, coat should be applied, in the case of lime stucco, after the first coat has thoroughly hardened, and when cement stucco is used, on the day following the application of the scratch coat. Screeds should be formed in the brown coat at 5-foot intervals to assist in bringing the surface to a true and level plane.

When the intermediate coat has sufficiently hardened, it should be floated with a wood float and firmly and evenly cross-scratched, or scored, to form a key for the finishing coat. On the following day and until the finishing coat is applied, the surface of cement stucco should be sprayed at frequent intervals, to keep it from drying out. This is not necessary with lime stucco, and is more necessary with cement stucco in warm weather than in cool weather.

153. Finishing Coat.—The third, or finishing, coat, in the case of lime stucco is applied after the intermediate coat is hard and dry; in the case of cement stucco, it is applied a week or more after the intermediate coat. This interval is necessary to allow the intermediate coat to obtain its initial shrinkage and to approach its final condition of strength and

hardness before being covered with the finishing coat. The finishing coat will vary from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch in thickness, depending on the finish desired.

154. Thickness of the Stucco.—On masonry walls the total thickness of the stucco for two-coat work, should not be less than $\frac{5}{8}$ inch, and for three-coat work not less than $\frac{7}{8}$ inch. On stucco boards, the thickness should be from $\frac{7}{8}$ to 1 inch. On wood lath, the finishing coat should bring the stucco at least $\frac{3}{4}$ inch over the lath, and on metal lath, to at least 1 inch outside the furring strips which support the lath. These thicknesses are determined by the thicknesses of the grounds. A variation in the total thickness of the stucco will occur on different parts of the wall, owing to surface irregularities which are brought to true planes by screeding.

On masonry walls, and on stucco-boards, the scratch coat and the intermediate coat are often applied in close succession, practically at one operation, but this is not desirable when the total thickness of the coat exceeds $\frac{1}{2}$ inch, as coats of that thickness have a tendency to bag or slip, producing an uneven and weak body for the finishing coat.

155. Drying Out.—The finishing coat should not be allowed to dry out rapidly. The surface of cement stucco, therefore, should be sprinkled frequently. Wet burlap, or similar materials, may be hung over the surface of cement stucco to keep it moist until it has set properly. Sprinkling is not necessary with lime stucco.

156. Freezing.—Neither lime nor Portland cement should be applied when the temperature is below the freezing point, or when it is apt to go below the freezing point within a few hours.

157. Back-Plastered Stucco Walls.—Stucco is sometimes applied to metal lath on studding without sheathing or papering. In this method, a coating of stucco is applied to the back of the lath as well as to the face, from which fact the method is called *back-plastering*. A section of a back-plastered wall is shown in Fig. 66. As the sheathing is

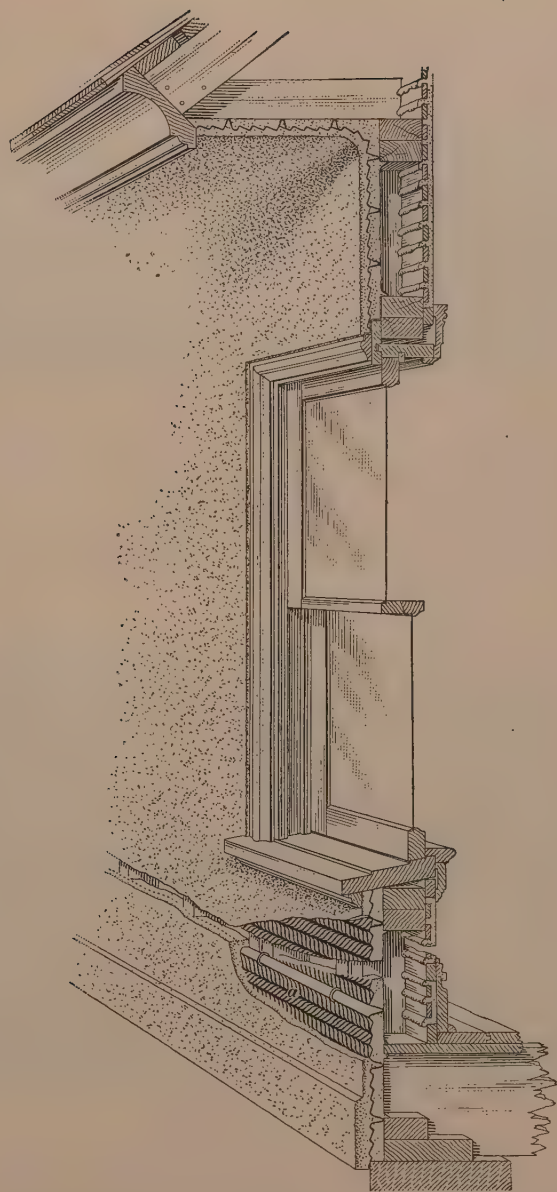


FIG. 66

omitted, the wooden framing of the structure must be particularly well braced.

158. Lathing for Back-Plastered Walls.—The lathing used for back-plastering is a combination lath and furring and the furring is applied across the studs. This assures an even thickness of plaster in front of the studs, as well as between them. Separate metal furring is sometimes used with plain metal lath stapled over it and into the wooden studs.

STUCCO FINISHES

159. The appearance of a stuccoed building depends largely on the finish of the stucco surface. Stucco finishes depend on texture and color, or on both in combination. Texture effects are due to the form of the surface, while color effects depend on the colors of the various ingredients used. As the color of the ingredients will be apparent in the various texture finishes, desired effects are generally obtained by a combination of texture and color.

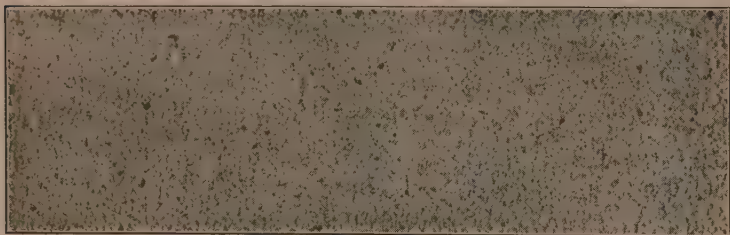


FIG. 67

160. Texture Effects.—The principal surface finishes which depend on texture for their effect are *smooth-troweled*, *stippled*, *sand-floated*, *sand-sprayed*, *rough-cast*, or *spatter-dash*, and *pebble-dash*. These finishes are shown in Figs. 67 to 72, inclusive, which are made from photographs furnished by the Atlas Portland Cement Company.

161. Smooth - Troweled Finish.—In the smooth-troweled finish, Fig. 67, the finishing coat is troweled smooth with a metal trowel. The surface should be rubbed as little

as possible, as continued rubbing or troweling is apt to bring an excess of cement to the surface. Excessive rubbing results also in fine hair cracks, which are readily discernible and are

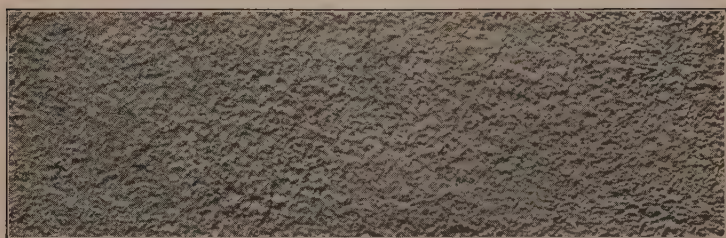


FIG. 68

objectionable in appearance. This finish is used sometimes in small panels, but is not satisfactory for large areas. In Fig. 59 are shown wall surfaces having smooth-troweled finishes.

162. Stippled Finish.—After the finishing coat has been brought to a smooth surface by troweling, it may be lightly patted with a brush of broom straw, to give an even, stippled, surface. This must be done before the cement has attained its initial set. A panel in this finish is shown in Fig. 68.

163. Sand-Floated Finish.—After the finishing coat has been brought to a smooth, even, surface, a little sand is sprinkled over the surface, and the surface rubbed with a

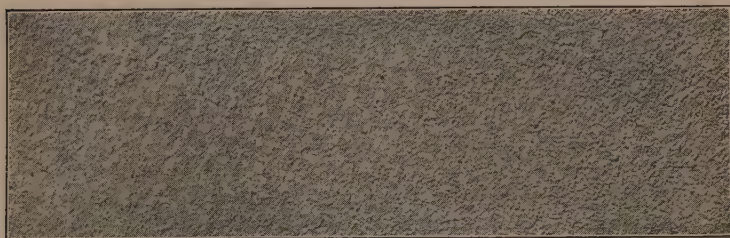


FIG. 69

wooden float, the float being worked with a circular motion. This floating should be done when the mortar has partially hardened. A panel with this finish is shown in Fig. 69.

164. Sand-Sprayed Finish.—When the finishing coat has been brought to an even surface, as in the smooth-troweled finish, it may be sprayed by dashing a creamy mixture of



FIG. 70

equal parts of Portland cement and sand against the surface by means of a wide, long-fibered brush, similar to a whisk-broom. The coating should be thrown forcibly against the surface to be finished, and should be applied while the finishing coat is still moist, before it has obtained its early hardening, that is, within 3 to 5 hours after the application of the finishing coat. The mixture should be made up fresh every 30 minutes and kept well stirred. A panel in this finish is shown in Fig. 70.

165. Rough-Cast, or Spatter-Dash, Finish.—To produce the rough-cast, or spatter-dash, finish, shown in Fig. 71, the finishing coat is first brought to a smooth, even

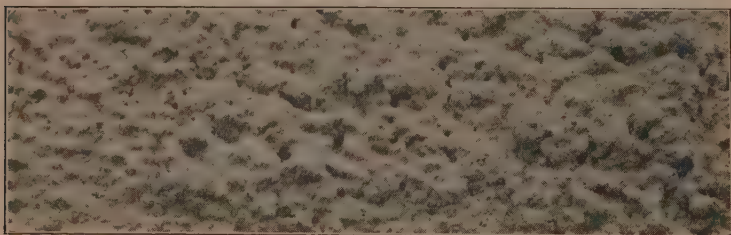


FIG. 71

surface by means of a wooden float. Before the surface has finally hardened, it is coated uniformly with a mixture in the proportions of 1 sack of Portland cement to 3 cubic feet of

sand or finely crushed stone, with enough water to make a stiff mixture. This is thrown forcibly against the surface so as to produce a rough surface that will appear to be of uniform texture. Special care must be taken with this finish to prevent too rapid drying out. To prevent this, it is necessary to wet the stucco at intervals after it has hardened sufficiently to prevent its being injured by the application of water.

166. Pebble-Dash Finish.—To produce the pebble-dash finish, shown in Fig. 72, the finishing coat is brought to a

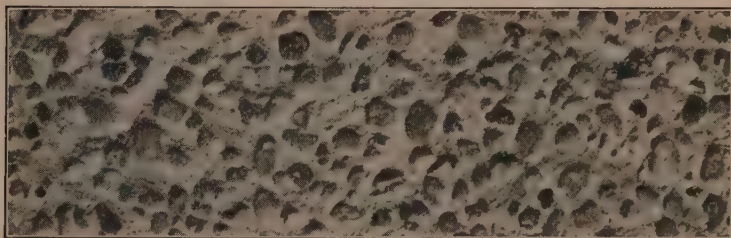


FIG. 72

smooth surface, as in the finishes just mentioned. Before the stucco begins to harden, clean, round pebbles, or such material as may be selected, $\frac{1}{4}$ inch or larger, and previously wetted, are thrown forcibly against the wall so as to embed them in the soft mortar. The pebbles should be evenly distributed over the surface of the finishing coat, and they may be pressed back into the stucco by means of a clean, wooden trowel, but the surface should not be rubbed after the pebbles are embedded. This finish is sometimes known as the *applied-aggregate* finish.

COLOR EFFECTS

167. Color effects in stucco may be secured by a selection of the ingredients of the finishing coat of stucco, or by the application of surface coatings. Aggregates may be obtained in a great variety of colors, and these colors may be produced in the surface of the stucco by exposing the aggregates in the surface of the walls.

Ordinary lime stucco will give a pleasing whitish-gray or light-buff color, depending on the color of the sand. Stucco composed of ordinary Portland cement and common sand will have a grayish, or mouse color, different brands of cement causing a slight variation in the color of the finish. Sand occurs in various colors, such as white, yellow, red, and brown, which produce corresponding effects on the color of the stucco. Where a pure white effect is desired, it can be obtained by the use of lime, or of white cement and white sand. Hydrated lime in cement stucco will give the stucco a lighter tone. The color of the stucco may be varied further by adding pigments, or mortar colors, to the finishing coat of stucco. Should the finished surface not have the desired color, it may be coated with a wash, or paint, to obtain a more satisfactory tone.

168. Exposed-Aggregate Finish.—There are two methods of producing the exposed-aggregate finish. In the first, known as the *integral* method, the aggregate is mixed with the mortar of the finishing coat. In the second, known as the *cast-on* method, the aggregate, which may be pebbles, crushed stone, or gravel, is applied to the surface of the finishing coat in the same manner as already described for pebble-dash finish.

In the integral method, the finishing coat, consisting of Portland cement, sand, and the desired aggregate, is brought to a smooth surface by means of a wooden float. When the cement stucco has hardened sufficiently, but before it has obtained its final hardness, the surface is scrubbed with a stiff brush and water, to remove the thin film of cement which covers the aggregate. When the cement cannot be removed by this scrubbing, a solution of 1 part of hydrochloric acid in 4 parts of water may be used. After the aggregate particles are uniformly exposed by scrubbing, all traces of the acid may be removed by spraying with water from a hose.

In Fig. 64 is shown a panel in which the color effect was produced by the use of a finishing coat composed of 1 part white Portland cement, 2 parts white sand and $\frac{1}{10}$ part hydrated lime. When the surface had been made smooth,

yellow gravel was thrown on the surface and lightly pressed in. In Fig. 65, a finishing coat consisting of 1 part white Portland cement and 2 parts white sand was used, but the aggregate consisted of 1 part yellow gravel, $\frac{1}{10}$ part green marble, and $\frac{1}{10}$ part black marble.

As a great variety of materials are available for use by these methods, the architect can secure practically any surface effects. An advantage of the exposed aggregate finish is that the colors, being those of the natural stone, are reasonably sure to be permanent. The advantage, obtained in the case of colors and stones, is obtained with natural sands.

169. Pigments and Mortar Colors.—When it is desired that any of the finishes mentioned be made with colored mortar, certain mineral mortar colors, or pigments, may be added to the finishing coat of stucco. When using these materials, it is advisable to use white cement and white sand, or, otherwise, the color of the pigments would be affected by the gray of the cement and by the color of the sand.

170. Coatings on Stucco Surfaces.—Coatings for new stucco surfaces are used for the purpose of securing a suitable color, a uniform appearance, and a more impervious surface. The surface to which the coating is to be applied should be free from dust, dirt, and loose particles, in order that the coating may adhere well. The coating may consist of a thin mixture of equal parts of Portland cement and sand, to which may be added hydrated lime, or other materials to produce the desired color.

171. Coatings containing various colored pigments may be obtained for covering the finished stucco surface. After application to the surface, the liquids either evaporate or are absorbed by the stucco, leaving the pigment attached to the surface. These coatings are applied by means of a brush, or with a hose having a spray nozzle, at any time after the finishing coat has hardened. These coatings may be used to change the color of the stucco after it has been in place for a time, and as they close the pores of the stucco, they have a certain amount of waterproofing value.

WATERPROOFING OF STUCCO

172. Need and Methods.—Stucco must be impervious to moisture, which would cause disintegration through rusting of the metal lath or nails, and through the action of frost, should the stucco become saturated. Should the moisture reach the wood frame, there is a possibility of swelling as well as decay. When the moisture extends through to the interior of the wall, the dampness makes an unsanitary dwelling. A stucco wall that absorbs moisture becomes discolored and apt to show efflorescence.

173. Moisture will not readily penetrate a dense wall, and one of the best methods of making a stucco wall impervious to moisture is to grade and mix the material in such a way that the voids and pores in the stucco are reduced to a minimum. Where the nature of the materials is such that an impervious wall cannot be formed in this manner, the stucco may be waterproofed by either of two methods, one known as the *integral method*, and the other known as the *applied-coating method*.

174. Integral Method.—One method of integral waterproofing is to add 1 pound of tallow to each bushel of lime in the slaking bed before it is slaked. This is an effective integral method of waterproofing for lime stucco. The heat generated during the slaking melts the tallow. The tallow turns to soap and melts, making with the lime an insoluble material which is impervious to water. In the case of cement stucco a small percentage of hydrated lime added to mortar is an effective integral method of waterproofing. The lime, or compounds, fill the voids in the stucco, and form chemical combinations with the Portland cement, the result being that absorption of water is prevented.

Other integral methods for waterproofing for both lime and cement stucco are being offered by manufacturers, sometimes being combined as a coloring and waterproofing material, although practically colorless waterproofing may be obtained.

175. Applied Method.—In the applied coating method, the waterproofing preparations, known as exterior waterproof-

ings, brick and cement coatings, damp-proofings, etc., are applied by means of a brush to the surface of the finished stucco, two or more coats being required usually to insure good results.

MAGNESITE STUCCO

176. Magnesite stucco contains the mineral magnesite as the principal ingredient. When mixed with a liquid such as chloride of magnesium, magnesite forms a dense, hard, rock-like, substance. Before adding the liquid, sand, asbestos, fine aggregate, and mineral colors are added to the magnesite. The liquid is then added to form a plastic material for use as stucco which may be used wherever lime or Portland cement stucco can be used.

Some of the well-known brands of magnesite stucco are *Elastica*, *Kellastone*, *Kragstone*, *Magnesite*, and *Robbond*. The exact proportions of materials in these stuccos are not stated by the manufacturers, who supply the materials ready to mix and apply.

177. Advantages.—An important feature of magnesite stucco is that the materials will not freeze at any temperature as low as 20° below zero, and so the stucco may be applied at practically any time of the year. The materials have a very high resistance to fire, and they insulate the building against heat and cold. When properly applied, a hard, dense, surface is obtained, making the building durable and dampproof.

178. Practically any of the finishes described for lime or Portland cement stucco may be obtained with magnesite stucco. In some cases the manufacturer is prepared to furnish the material of any color desired. At other times, the plasterer must mix in the color when the stucco is applied.

Magnesite stucco may be applied to surfaces of brick, hollow tile, cement blocks, concrete, or to wood, or metal, lath, stucco board, or similar bases.

179. Preparation of Surfaces.—The same care necessary in preparing the base for Portland cement stucco should

be followed when magnesite stucco is to be applied. When wood lath is used, the joints between the lath should be kept thin, about $\frac{1}{8}$ inch being recommended. At all corners and openings, metal lath should be applied to aid in preventing cracks.

180. When masonry walls are to be covered with magnesite stucco, care must be taken to insure a clean roughened surface. When a satisfactory surface cannot be obtained, as may occur with an old brick wall which has been painted, or disfigured by oil or smoke, the wall should be covered with coarse-mesh, metal lath, securely attached to the wall. In some cases, it may be advisable to drive large flat-headed nails into the mortar joints at frequent intervals, leaving the heads projecting. The stucco hardens around these nail heads and is anchored to the brickwork.

181. Masonry walls must be dry and free from frost when magnesite stucco is applied. While the materials in the stucco will not readily freeze, any moisture or frost in the walls will prevent the stucco from adhering firmly.

182. Application of the Stucco.—Magnesite stucco usually is shipped ready to mix with the liquid furnished. In some cases, sand or other fine aggregate may be added. The materials should be mixed only as required, as retempering is not possible after the materials begin to set.

183. Magnesite stucco usually is applied in two coats; the first, or *scratch coat*, and the second, or *finish coat*. When an additional finish of crushed aggregate is added, this sometimes is called a *dash coat*.

184. First Coat.—Before any stucco is applied, it is advisable, usually, to brush masonry surfaces with the mixing liquid. The first, or scratch, coat usually contains, besides the magnesite and mixing liquid, certain qualities of washed and graded sand. There may be also added long-fibered asbestos to serve as a binder, and granulated cork for insulation and filler. This coat is generally $\frac{1}{4}$ to $\frac{3}{8}$ inch thick.

185. Second Coat.—The second, or finish, coat is composed of practically the same materials as the first coat, with the exception that shorter-fibered asbestos may be used, and mineral colors added to give the desired tone to the stucco. The surface of the first coat may be brushed with the mixing liquid before applying the second coat, as this will tend to cause a firmer bond between the two coats. The second coat generally is $\frac{1}{4}$ to $\frac{3}{8}$ inch thick, and any irregularities in the wall surface must be taken up in this coat. The total thickness of the stucco should never be less than $\frac{1}{2}$ inch in the thinnest part, and a thickness of $\frac{3}{4}$ to 1 inch is preferable.

186. Surface Effects.—Surface effects in texture and color similar to those described for Portland cement stucco may be obtained with magnesite stucco by using similar methods.

MISCELLANEOUS

WHITEWASHING

187. Whitewash, a lime preparation used for coating masonry, concrete, and wood surfaces, either on exteriors, or in basements, cellars, and underground rooms, and passages, is useful for preventing decay in wood, and valuable as a sanitary material. The whitewashing often is included in the plasterers' work.

188. Common whitewash is made by slaking lump lime, and adding sufficient water to make a thin paste. By using 4 pounds of sulphate of zinc and 2 pounds of salt to each bushel of lime, the whitewash will be rendered much harder and will be prevented from cracking readily. The durability of whitewash, especially for outside work, may be increased by mixing 1 pint of linseed oil with each 2 gallons of whitewash, immediately after the lime is slaked. Whitewash may be tinted by the use of yellow ocher, Indian red, raw umber, indigo, bluing, or lampblack, the bleaching power of lime destroying most other coloring materials.

189. Whitewash may be applied to clean surfaces by means of a brush. When large surfaces are to be coated, it is economical to use a pump and hose which has a spray attachment. Rough and porous surfaces will take whitewash better than smooth and impervious surfaces. For new work, two coats should be applied, the first coat being allowed to dry before applying the second.

OVERCOATING

190. Overcoating is the process of covering the frame or exterior of an old building with stucco. The term is more generally used in connection with frame buildings, but the process is equally applicable to masonry buildings, in which case the previous directions as to stuccoing on existing masonry walls should be observed. Either lime stucco, Portland cement stucco, or magnesite stucco, may be used for overcoating.

191. Advantages of Overcoating.—When the exterior of a building becomes unsatisfactory in appearance, and fails to protect the building against the elements, the process of overcoating may be employed to improve the appearance of the building, and to render it less subject to weather conditions.

192. Precautions to be Observed.—Before commencing the overcoating, the building should be carefully inspected to determine whether it is in satisfactory shape to receive the work, and whether the expense will be justified. The frame of the building must be sound, the doors and windows made true, and the walls plumbed, before the work proceeds. While this is not the work of the plasterer, he must see that it is all in proper condition before he can hope to do satisfactory work.

193. Particular attention should be paid to the roof and to the drainage system. A tight roof is essential, and such repairing must be done as will insure against any leakage that might get in back of the finished stucco. Especial attention must be paid to the details of flashings and drips. A careful

design of the building at these points will prevent discolorations and disintegration due to water finding its way back of the stucco.

194. Masonry Buildings.—Stucco can be applied directly to the surface of masonry walls, provided that thorough cleanliness, a good mechanical bond, and proper absorption may be obtained. It is most important that masonry walls be clean before the stucco is applied. When the masonry surface cannot be brought to the condition of a base that will hold the stucco firmly, the surface should be furred out and lathed as is done for new work.

195. Frame Buildings.—When frame buildings are to be overcoated, they should be made structurally sound in every respect. If the old siding is in poor condition, so that the furring and lath cannot be held firmly, the siding should be removed, the walls covered with waterproof paper, and then furred and lathed, in the same manner as described for new work.

When it is necessary to remove the sheathing as well as the siding, the studs should be braced, and furring and lathing applied as described for back-plastered walls.

196. Where overcoating it to be done over beveled siding, flush, or novelty siding, clapboards, or shingles, the furring and lathing will cause the face of the stucco to be some distance out from the original surface, usually so far that the cornice, sills, and trim, will not show properly. It will be necessary to fur out for the new positions of cornice members, and to reinforce the outside edge of window sills to conform to the new outside surface of the walls. A face molding of suitable size will be required around the edges of window, and door, casings, and other trim must be built out as required. All the trim should be placed in such a manner that it will show its proper projection in relation to the finished stucco surface.

A typical method of adapting overcoating to a building having beveled siding is shown in Fig. 73. A new molding is placed at *a*, against which the stucco finishes. The trim of the window is built out by means of a new cap *b*, the lower mold-

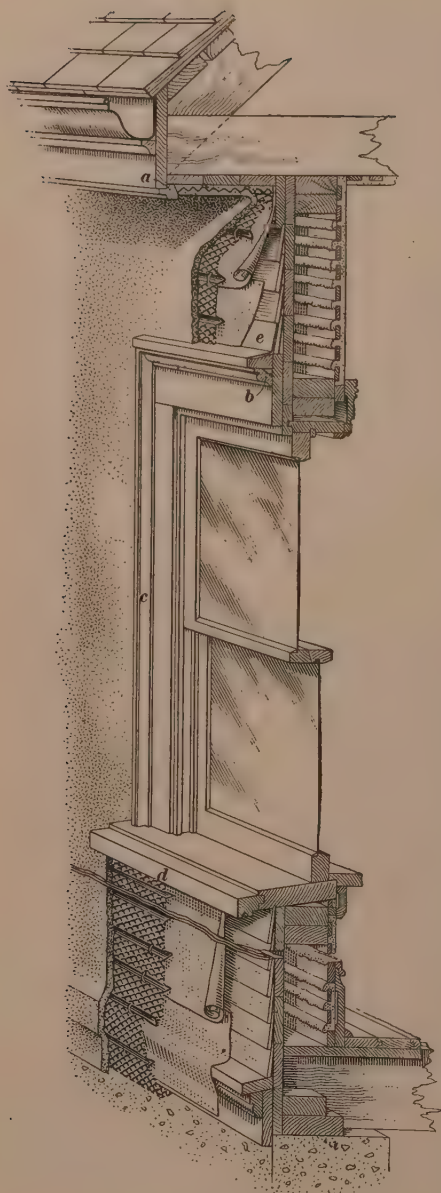


FIG. 73

ing of which extends down the jambs at *c*, to an extension sill *d*. The backs of moldings *a* and *c* are beveled, so as to cover the joint between the molding and the stucco, and to hold the stucco firmly in place. Flashing *e* is built in over the head of the window to prevent any water from getting back of the woodwork at that point. Ribbed furring lath is then placed on the siding, or furring may be used to support plain lath.

Ordinary wood lath is sometimes used for furring, but it is not as desirable as furring $\frac{5}{8}$ inch thick, as there is less space for plaster behind the lath.

It is always desirable, when overcoating over sheathing or siding, to cover the surface with waterproof paper before applying the furring, as this will keep the moisture of the stucco from being absorbed by the siding. It will also make a warmer house in winter.

HOLLOW TILE

ADVANTAGES AND NATURE OF HOLLOW TILE

1. Introduction.—Hollow terra-cotta blocks have been used for many years as a means of protecting the steel constructional parts of tall buildings from fire, as well as for constructing fireproof partitions, furring, etc. The employment of hollow terra-cotta blocks for the outside walls of buildings, particularly of residences, is more recent. Their use for this purpose is, however, quite extensive, and hollow-tile construction for walls of buildings has become thoroughly standardized. This style of construction is being used with increasing frequency where low-priced fireproof buildings are in demand.

2. Advantages of Hollow-Tile Construction. There are several advantages claimed for hollow-tile construction. Compared with wooden construction, it has the advantages that any masonry construction has over wooden construction; namely, greater stability, durability, and fire-resisting qualities, as well as a lower cost of maintenance. No matter how carefully a frame building is built and regardless of the excellence of the materials used and the high quality of the labor employed, its life is comparatively short. It must be kept in repair, and there is an increasing necessity for repairing as time goes on. Hollow-tile buildings, of course, also will need repairs, but the repairs necessary to keep a tile building in good condition are very much less than for a frame building. Hence, although the first cost of a building of hollow-tile con-

struction is greater than one of wooden construction, the ultimate cost, including cost of maintenance, when extended over a period of years, is less for the tile construction.

3. In the United States, where wood has been very plentiful and comparatively cheap, frame construction has flourished, but the enormous loss by fire in frame buildings is gradually leading to the erection of fireproof buildings of masonry.

Since tile is made of clay and has been thoroughly burned, it has fire-resisting qualities similar to those of brick, and buildings made of it can obtain low insurance rates.

For garages, hollow tile is one of the best materials that can be used, since it is not only economical and durable but possesses the most important requisite of any well-designed garage, that it shall be fireproof. It is not necessary to plaster the tile on the inside of a garage, as the wall can be made attractive by selecting tile with one face smooth or glazed and carefully pointing up the joints.

4. Another claim that is made for hollow tile is that it is sanitary and vermin proof, which makes it particularly adaptable for use in residences.

5. A further advantage of hollow-tile construction is that it is generally less expensive than any other form of masonry construction. This is an important consideration in the minds of architects and their clients. This economy in first cost is brought about partly by the nature of the hollow tile. Each tile is much larger than a brick and can be laid much more quickly than an equal volume of brickwork. A workman can, consequently, lay more cubic feet of wall with tile than he can with brick in a working day. The tiles are easily manipulated and can be broken and trimmed to fit peculiar conditions that are found when building walls.

Hollow-tile walls are strong and light in weight, which makes the load on the footings less than that of a solid brick wall. This saving in weight means an economy in the size and cost of the footings.

6. Another advantage claimed for hollow-tile construction is that the walls and floors are hollow. Each block of hollow tile consists of a sort of clay box divided by interior webs or partitions so that a wall built of hollow tile is honeycombed with holes. These holes, or cells, are excellent in many ways. For instance, the dead air contained within these cells provides excellent insulation against temperature changes, so that a hollow-tile wall is usually warmer in winter and cooler in summer than a wall of solid masonry. These cells also prevent the penetration of water through the walls.

7. It is claimed that interior plastering can be safely applied directly to the hollow-tile blocks, thus saving the cost of furring and lathing. It is not considered good practice to plaster directly upon the inner surface of a solid brick or stone wall, as dampness often works its way through and is apt to stain the surface of the plaster and to destroy decorations or papers that may be applied to the plaster.

8. Walls of hollow tile are easily arranged to contain heating and plumbing pipes as well as electric wires and conduits, either by building chases in the wall in advance of the installation of the pipes or by placing the pipes first and building the blocks around them. A common method, when the cells are set vertically, is to break slots or chases in the completed wall when it is time to run the pipes. This is easily accomplished, as the webs are quite thin and can be broken by sharp blows of a hammer and chisel. Care must be exercised, of course, in breaking into the finished wall to avoid damaging it too much.

9. Manufacture of Terra-Cotta Tile.—The manufacture of terra-cotta hollow tile is a comparatively simple process and consists, briefly, of kneading clay until it is of the proper consistency for molding, after which it is shaped into blocks and then baked in kilns.

10. Density of Terra-Cotta Tile.—Hollow terra-cotta tile is made in various densities, and three classes of the material are commonly recognized; namely, *dense*, *semiporous*,

and *porous*. These terms, however, are somewhat indefinite. For instance, when a kiln of tile is burned, the material closest to the fire is burned the hardest and consequently is dense, while the remainder of the tile in the same kiln might be classified as semiporous. Porous tile is of a different composition, and when burned is filled with numerous air spaces which make this material light and porous.

Most of the tile now manufactured is of the semiporous class because semiporous tile has been found by experience to be the most satisfactory ware.

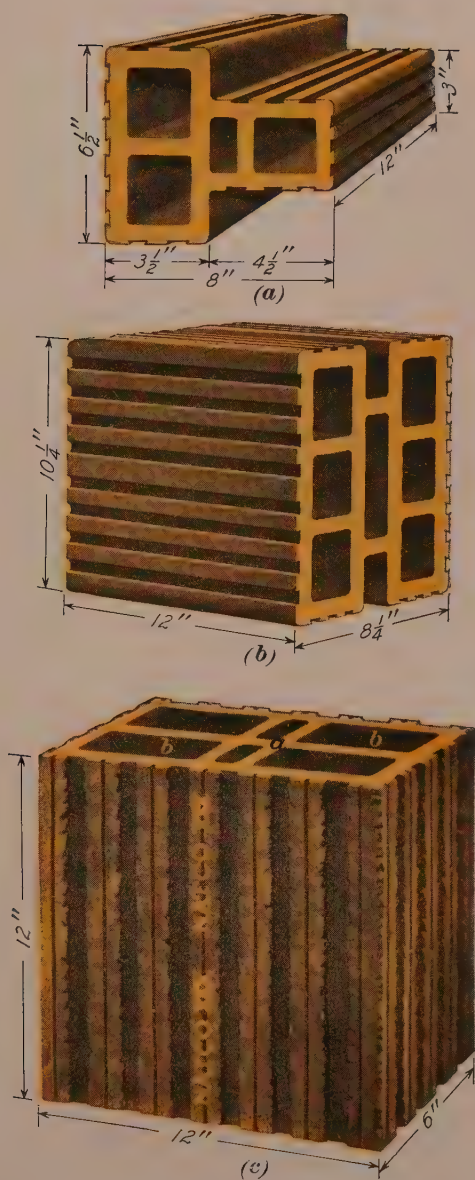
A frequent requirement of building codes regarding the density of tile is as follows: "Tile used for bearing walls shall not have more than 12 per cent. absorption." That is, the tile when immersed in water shall not absorb more than 12 per cent. of its weight of water.

11. Dense Tile.—Dense tile, being burned the most, is therefore hardest and strongest, and is used where heavy loads are to be supported. It is used where walls are to be veneered with brick or where the tile is exposed to the weather. Unless the surface is scored, or grooved, plastering will not adhere to the surface of dense tile.

12. Semiporous Tile.—Semiporous tile is the kind most used in houses and small buildings. Tile of this class is sufficiently hard burned to be fairly impervious to moisture and to make good substantial walls, but not too dense to prevent plaster adhering to it strongly. The tiles are, nevertheless, generally scored or grooved so as to afford a good bond for plaster or mortar.

13. Porous Tile.—Porous tile is rarely used and should never be employed for any purpose except for building inside walls, or partitions.

14. Glazed Tile.—Tile for certain purposes is sometimes glazed. Glazing is done by introducing a quantity of common salt into the kiln when the material is nearly burned and this produces a glass-like film over the entire exposed surface of



the tile. This tile must be grooved if it is to be plastered, as plaster or mortar will not adhere strongly to a glazed surface.

15. Vitrified terra cotta is generally made of fireclay or shale and is burned at a high temperature so that the material begins to fuse and is extremely hard throughout. This form of terra cotta is the densest kind, and is used for silos and other buildings in which the surface of the tile is exposed directly to the weather.

SHAPES AND KINDS OF HOLLOW TILE

16. Forms of Hollow Tile.—Hollow tiles used for the erection of the walls of buildings are made in three different general forms. These forms are shown in Fig. 1. In (a) is a **T**-shaped tile, known as an *interlocking tile*; in (b) an **H**-shaped tile, known as a *load-bearing tile*; and in (c) a regular, or box-shaped, tile. All these forms consist of units of burnt clay having outer shells and thin partitions, or *webs*, which divide the blocks into *cells*. These webs are shown at *a*, and the cells at *b* in (c). The shells are about $\frac{3}{4}$ inch and the webs about $\frac{1}{8}$ inch in thickness.

REGULAR, OR BOX-SHAPED, TILE

17. Description of Regular Tile.—In Fig. 2 are shown illustrations of some of the forms in which regular tiles are made. The blocks shown at (a) and (b) are used for closers and face blocks, as will be shown later on. Those at (c) and (d) are for building straight walls of different thicknesses. The blocks shown at (e), (f), (g), and (h) are modified forms of these regular blocks and are manufactured by the National Fire Proofing Company. They are known by the name of *Natco* hollow tile. Fig. 1 (c) is an illustration of a standard Natco block, showing in detail the arrangement of webs and the dovetailed scorings which are designed to afford a good grip for mortar and stucco.

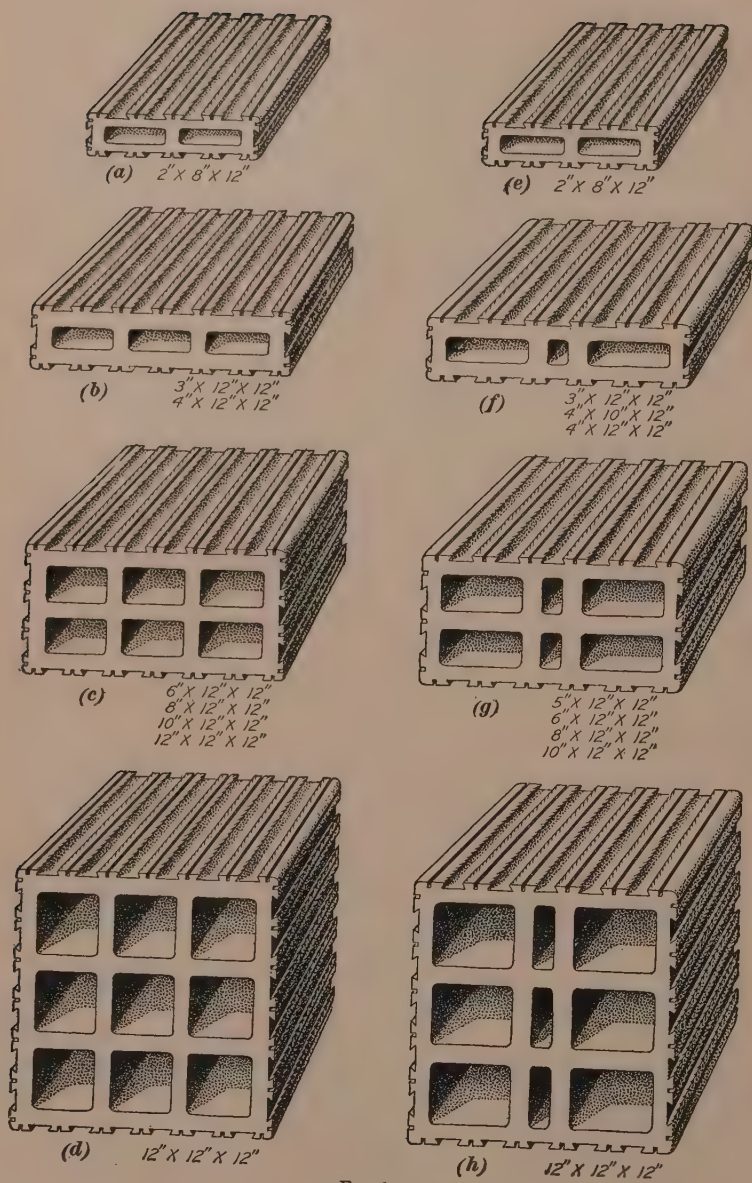


FIG. 2

By special arrangement of the webs and cells which is shown in Fig. 1 (c) and in Fig. 2 (g) and (h), the webs of the block above always rest directly upon the webs of the block beneath

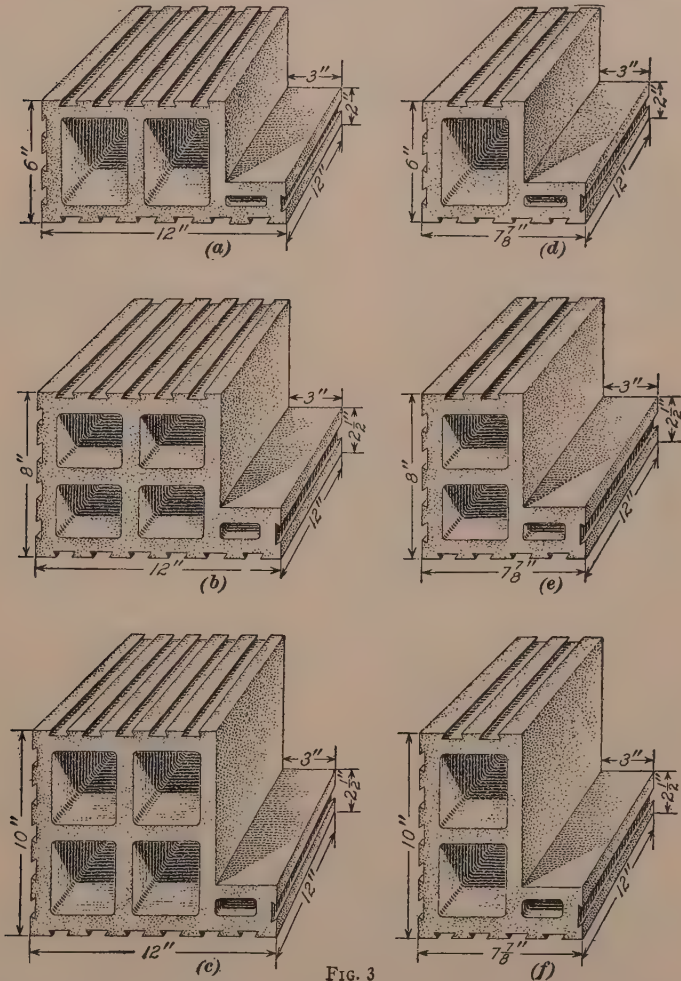


FIG. 3

when the joints are broken. The load on the tile is thus carried down to the ground by continuous webs of solid terra cotta. This also brings the cells into a continuous line from the top to the bottom of the wall so that they are available as pipe chases.

In Figs. 3 and 4 are shown jamb blocks and half jamb blocks, which are used for the jambs or sides of window open-

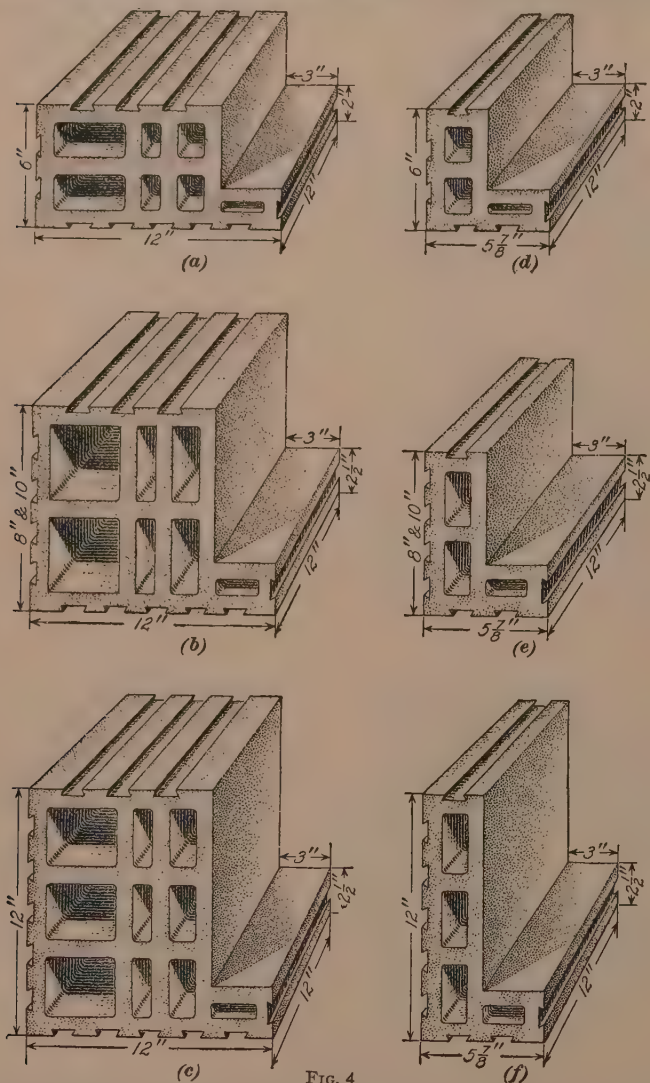


FIG. 4

ings when box window frames are used. In Fig. 3 are those that are used in connection with the regular blocks, and in Fig. 4

are similar blocks that are used in connection with the Natco blocks.

18. In Fig. 5 are shown box-shaped hollow tiles, made by the National Fire Proofing Company, which possess features that differ from those of the blocks already mentioned. For instance, these blocks are 5 inches in height instead of 12 inches and have double shells on the outer and inner faces

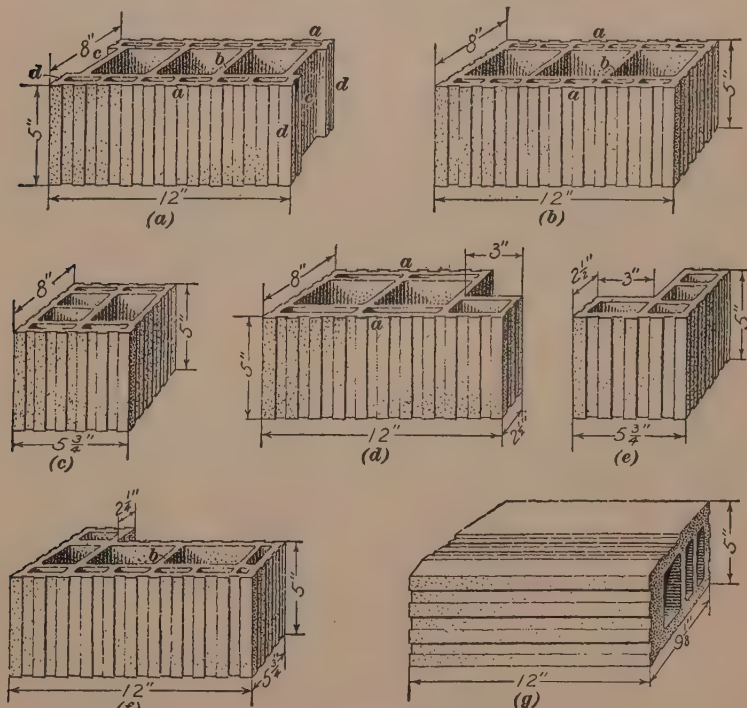


FIG. 5

of the principal blocks as shown at *a* in the different views in the figure. The cross webs *b* serve to tie the two faces *a*, *a* together, as shown in (*a*), rather than to support loads. Another feature that is different is the formation of the ends of the wall blocks (*a*). They are made with a hollow space *c* at each end so that the mortar joint does not extend through the wall but is placed on the surfaces *d* only. When the blocks

are set in place together this hollow space breaks the continuity of the mortar joint.

In Fig. 5 (a) is shown a standard wall block, in (b) and (c) *closure* tiles, or *closers*, for closing the ends of the cells in the tile at the end of a wall or at a door jamb. Jamb tiles and half jamb tiles are illustrated in (d) and (e), a corner block is shown in (f), and a sill block in (g).

Fig. 6 (a) shows a section taken vertically through several of these wall blocks, in which the double shells are at *b, b* and the webs at *a, a*. The mortar *c* is placed between the double shells only, and not between the webs at *d*. This breaks the continuity of these mortar

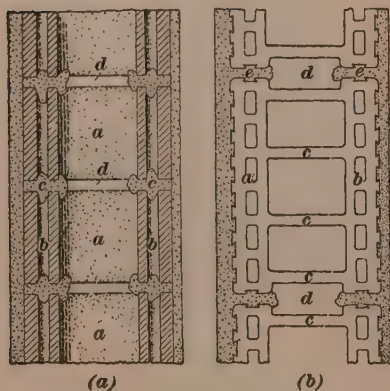


FIG. 6

joints. In (b) is a plan, in which the double shells are shown at *a* and *b* and the vertical webs at *c*. The air spaces between the ends of the blocks are at *d, d*, and the mortar joints between the ends of the tiles are at *e, e*.

19. The bulk of the wall, when regular tile is used, is composed of standard units, each consisting of a cellular

block of tile, $8'' \times 12'' \times 12''$ tile being used for an 8-inch wall, $10'' \times 12'' \times 12''$ for a 10-inch wall, and $12'' \times 12'' \times 12''$ for a 12-inch wall.

Units of different thicknesses are often used in the same structure, since it is often desirable to make the wall in one portion of a building thinner than in some other portion, the upper walls of a building often being made thinner than the lower ones.

20. Method of Setting.—The regular, or box-shaped, forms of tile are generally set with the webs and cells in a vertical position so that the edges of the blocks are over each other on the outside and inside faces of the wall. The blocks

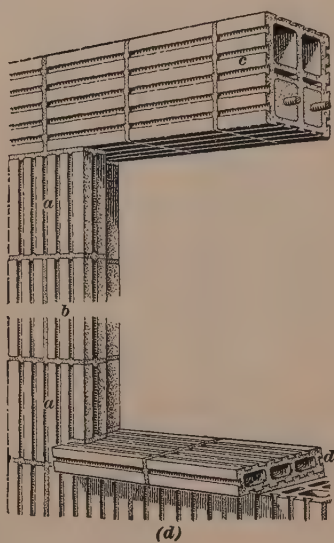
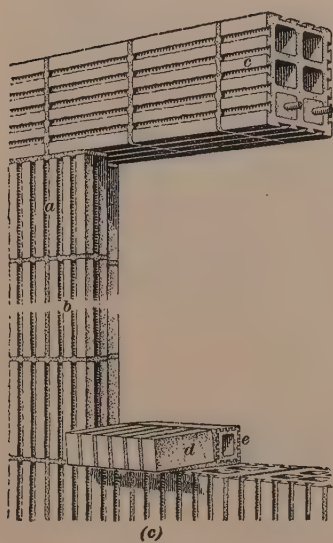
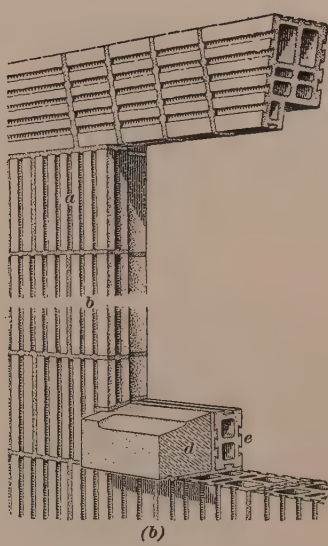
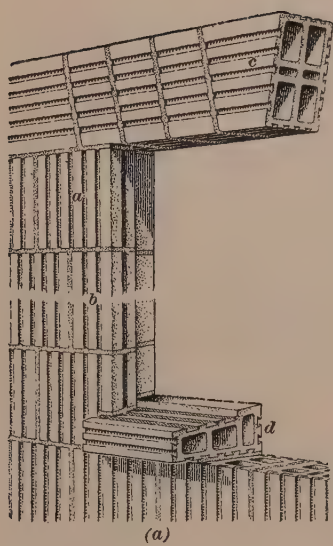


FIG. 7

are staggered over those below; that is, the vertical joint between two blocks is over the middle of the block below.

These tiles, set with the cells vertical, yield the maximum amount of strength. They are, however, sometimes set with the cells in a horizontal position, and for the ordinary loads that occur in dwellings, small factories, and other minor structures they are sufficiently strong when set that way.

21. The method of setting blocks with the cells vertical affords an easy means of forming chases for pipes and also allows of forming concrete piers beneath concentrated loads

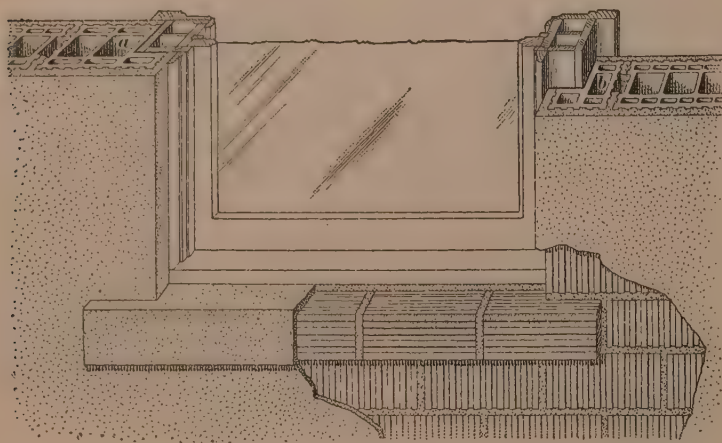


FIG. 8

that may occur in the structure. These concrete piers can be formed by simply filling a number of the cells below the special load with concrete, which sets and forms a strong vertical support, or pier.

Where the blocks are set with the cells in a horizontal position, it is difficult to cut chases and impossible to form special piers with concrete as just described. In such a case the chases must be formed as the wall is built, as will be described later.

22. Special Shapes.—There are several special shapes in hollow-tile blocks that are used in connection with the regu-

lar tile; some of these shapes are *jamb blocks*, *lintel blocks*, *sill blocks*, and *solid slabs*.

23. Jamb Blocks.—Jamb blocks, shown in Fig. 3, are used where box window frames are installed in a building. These blocks contain a rabbet into which the window frame is set. The use of jamb blocks and half jamb blocks is illustrated in Fig. 7, where at *a* are shown jamb blocks and at *b* half

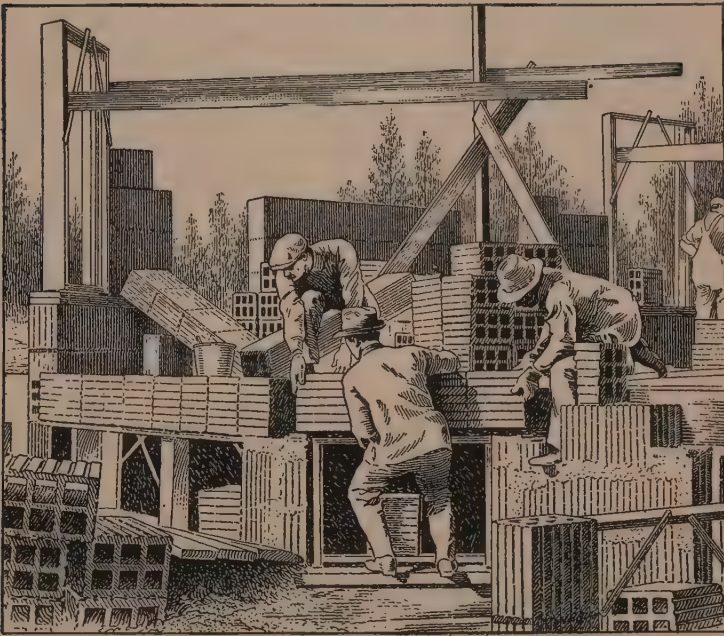


FIG. 9

jamb blocks, which are used alternately in the height of the wall in order that the wall blocks may break joints and also bond in strongly with the window jambs. Jamb blocks *a* and half jamb blocks *b*, for use in connection with the blocks shown in Fig. 5, are shown in Fig. 8.

24. Lintel Blocks.—Lintel blocks are used to form lintels over door and window openings that are not over 5 feet in width. One type of lintel block is made in the shape of a

voussoir or arch stone, so as to form a flat arch as shown in Fig. 7 (a). Another form of block, shown in (b), also

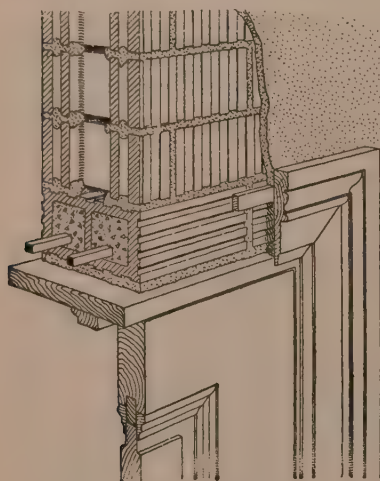


FIG. 10

forms a flat arch and has a rabbet *c* which is designed to receive the top of the window frame. The lintels most frequently used in practice are shown in (c) and (d), and consist of several standard blocks placed together as illustrated. These blocks are piled up on end, steel rods are placed in the cells that are to be the bottom ones when the lintel is in place, and these cells

are filled with concrete or strong mortar. The rods extend throughout the entire lintel and provide tensile strength for the bottom of the lintel. When the concrete or mortar has thoroughly set, the lintel may be lifted and set in place in the same manner as a stone lintel, as illustrated in Fig. 9.

A form of lintel used with the blocks shown in Fig. 5 is illustrated in Fig. 10.

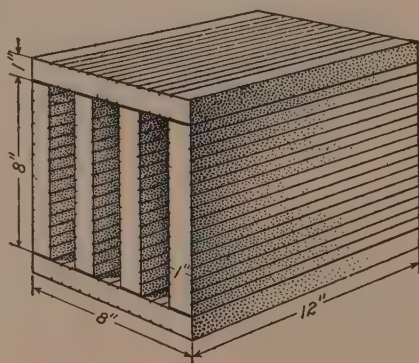


FIG. 11

25. Sill Blocks. —

Tile for window sills can be obtained in the form shown at *d* in Fig. 7 (a).

This sill is made with a suitable wash and rabbet, and is grooved to hold a stucco coating. Another form of sill is shown at *d* in (d) and con-

sists of standard tiles 2 inches or 3 inches thick and laid either flat or with a slight slope. This sill is also designed to receive a coating of stucco. Other sills are used in connection with hollow-tile construction, such as the stone sill shown at *d* in (*b*) and the brick sill *d* in (*c*). The sill in (*c*) may be constructed of hollow terra-cotta tile of brick size, or of ordinary brick and covered with stucco; or it may be formed of face brick and show the brick surface on the finished sill. Stone or brick sills are sometimes backed with terra-cotta blocks, as shown at *e* in (*b*) and (*c*).

26. Solid Slabs.—Solid slabs, 1 inch in thickness, are made for use under beams. They are laid over the cells on top of the regular wall blocks to form a continuous bearing for floorbeams, as shown later. These slabs are delivered at the building in the form of boxes resembling the regular box tile, as shown in Fig. 11. When tapped on the corner, these blocks fall apart into 6 flat slabs. The sizes in which these slabs are made are 1 in. $\times$ 8 in. $\times$ 10 in.; 1 in. $\times$ 6 in. $\times$ 12 in.; and 1 in. $\times$ 8 in. $\times$ 12 in.

T-SHAPED TILE

27. Form and Use.—As indicated by the name, T-shaped tiles have a shape similar to that of the capital letter **T**, as is shown in Fig. 1 (*a*) and also in Fig. 12. This type of tile is laid with the cells in a horizontal position.

The particular advantages claimed for the T-shaped tile are, first, that the shape of the tile breaks the direct mortar joint between the outside and inside surfaces of the wall. This will be seen in Fig. 12, where in (*a*) is shown an 8-inch wall, in (*b*) a 12-inch wall, and in (*c*) a 16-inch wall. In all these walls it will be seen that the mortar joints *a* are interrupted by the air spaces *b*, so that moisture cannot penetrate through the wall by way of the mortar joints.

The second advantage claimed is that no air space in one course of tile communicates with air spaces in the next course above or below, hence there is less circulation of air than when the cells are placed vertically.

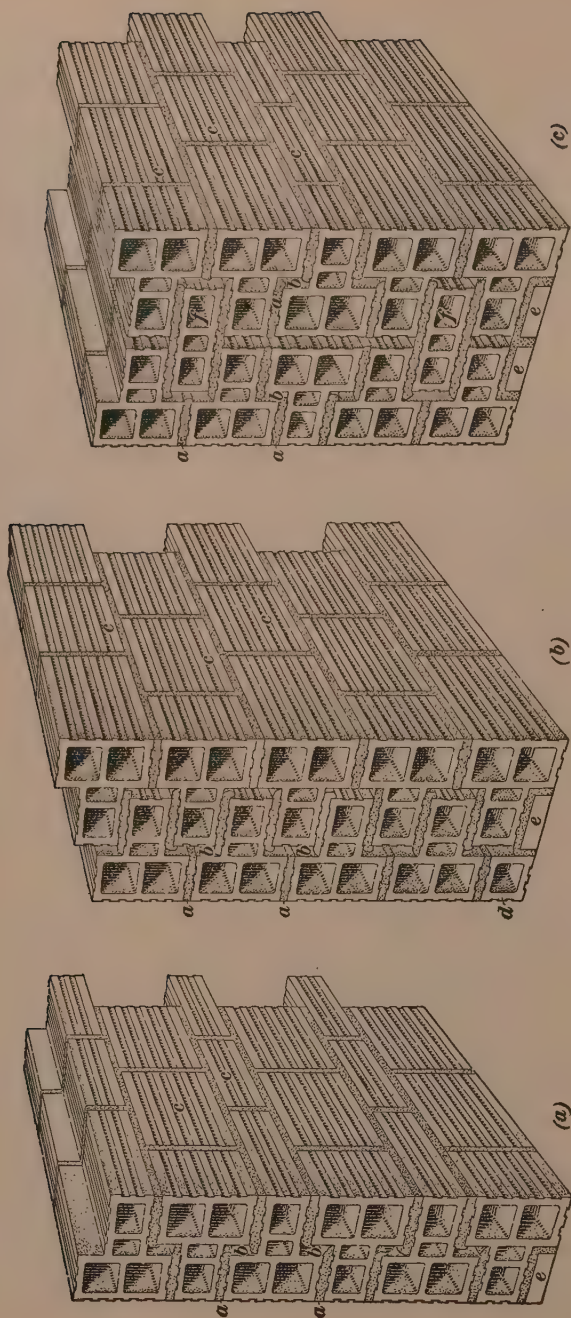


FIG. 12

28. Special Shapes.—As in the case of the regular tile, special forms or shapes are required when using T-shaped tile for the jambs of windows, where box frames are used, as well as for sills, lintels, corners, starting blocks, etc.

29. Jamb Tile.—The form of tile used for jambs in connection with T tile is shown at *a* in Fig. 13 (*a*). The large dovetail grooves *b* in the wall side of this tile are for the reception of steel anchors *c* which fit into the grooves as shown in

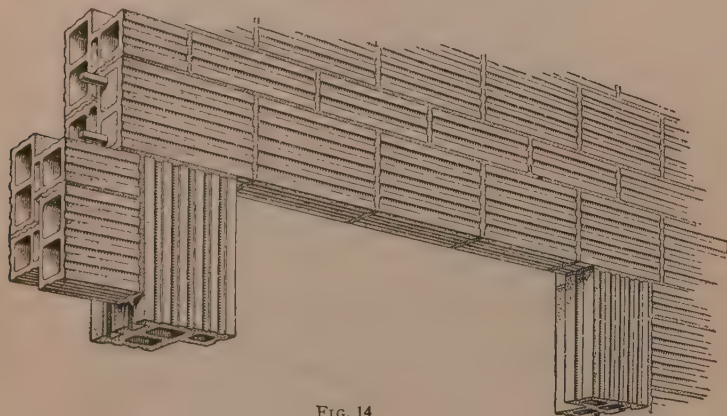


FIG. 14

the figure and tie the jamb blocks firmly to the wall. In (*b*) is shown a plan of one of these anchors. A plan of the jamb block is shown in (*c*).

30. Lintels.—Lintels are formed by piling the required number of wall tiles on end and filling the cells with concrete, steel bars first being placed in the cells that are to be the upper and the lower cells when the lintel is in place. When the concrete has set, these lintels are set in place in the same manner as stone lintels. It is not safe to use a lintel of this type for an opening more than 5 feet in width. An illustration of a lintel formed of T-shaped tile is given in Fig. 14.

31. Chases.—In walls, vertical chases for the accommodation of soil and steam pipes, etc. are made in the form shown

in Fig. 15, by using the standard **T** tile as far as possible and filling in with pieces of tile obtained by cutting the standard tile or with bricks. In (a) is shown a chase in an 8-inch wall, and in (b) a chase in a 12-inch wall. These chases are covered with wire lath as shown in (b), and the plastering is continued across the chase opening.

32. Corner Tile.

In building a wall of standard **T** tile there will always be certain spaces left at the corners of the wall that will require special-shaped tiles to fill them out properly. In Fig. 13 (a) is an 8-inch wall which shows the spaces left to be filled with special corner tiles after the regular **T** blocks have been used as far as possible. The blocks *d* and *e* in (a) represent the corner blocks required for this purpose. The smaller block *e* is merely one-half of a block such as *d*. The blocks *d* are $6\frac{1}{2}$ inches high and are scored or

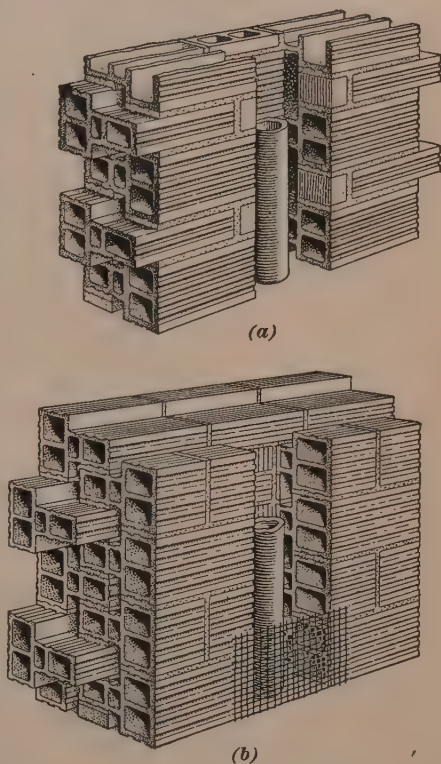


FIG. 15

marked so as to be broken easily into two $3\frac{1}{4}$ -inch blocks when required. For 12-inch walls the same corner block as at *d* is used, as shown in Fig. 16 at *a* and *b*. These blocks are $6\frac{1}{2}$ inches in height and are used in both positions.

33. Starting Blocks.—It is necessary in starting a **T**-tile wall upon a level surface to use starting blocks as shown at *d*

and *e* in Fig. 12. The block *d* is a one-celled block while *e* is a solid piece of terra cotta or brick.

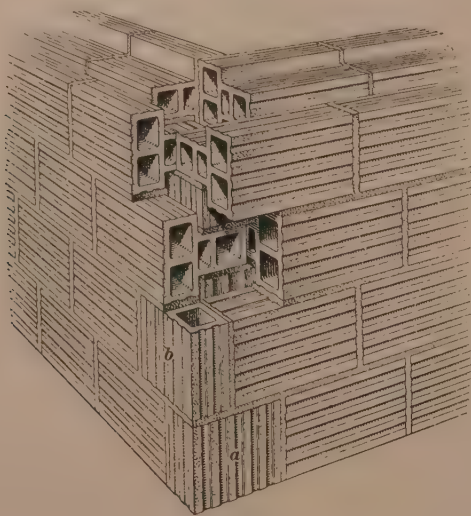


FIG. 16

34. Bonding Tile.—A special tile, shown at *f* in Fig. 12 (*c*), is required for walls 16 inches or more in thickness to complete the bond properly.

H-SHAPED TILE

35. Form and Use.—H-shaped tiles are also usually laid with the cells in a horizontal position, and the same advantages are claimed for them as for T-shaped tile. The H-shaped tile is illustrated in Fig. 17. At *a* in (a) is shown an $8\frac{1}{4}'' \times 10\frac{1}{4}'' \times 12''$ block. The height of this block, $10\frac{1}{4}$ inches, is the same as that of four bricks and three mortar joints; the block shown in (b) is $7\frac{5}{8}$ inches, or three bricks and two mortar joints, in height; that shown in (d) is $8\frac{1}{4}$ in. $\times 5\frac{1}{8}$ in. $\times 12$ in., or two bricks and one mortar joint in height. The block shown in (c) is about the size of a common brick but 12 inches in length.

The slots in the tops and bottoms of these blocks serve to break the mortar joint so that it will not be continuous through the wall. This is shown in (a) and (b).

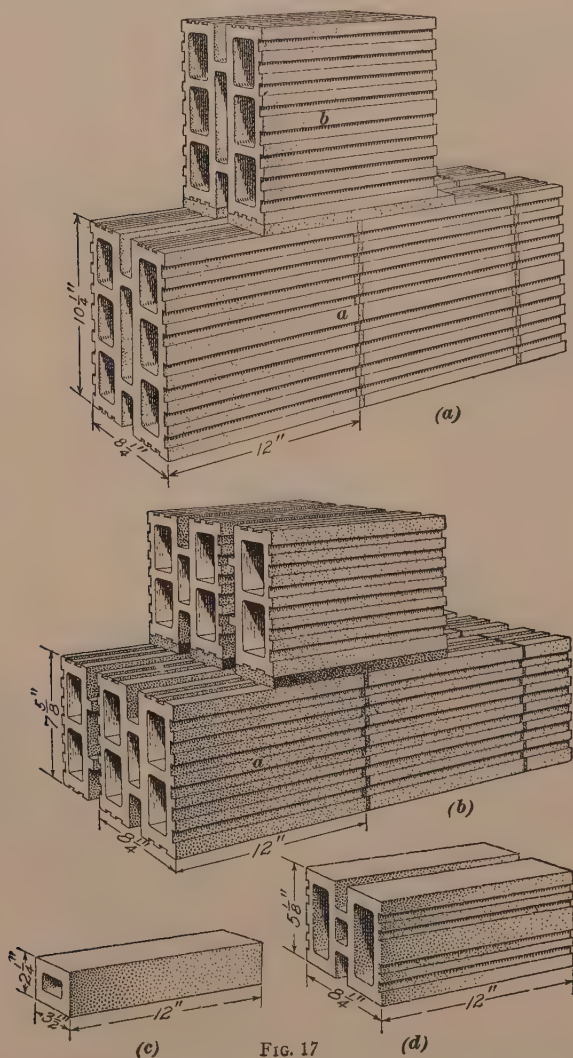


FIG. 17

In (a) is shown the method of laying the blocks in an 8 1/4-inch wall and in (b) in a 13-inch wall.

H blocks have four heavy vertical webs which come above each other in the successive layers of blocks and thus form continuous webs from the foundation to the top of the wall. The surfaces of these blocks are finished with deep grooved scoring, scratched scoring, or smooth.

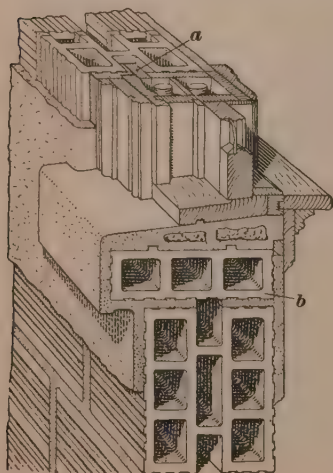


FIG. 18

36. Jamb Tile.—Jamb tiles may be formed by standing the regular **H** tiles with the cells vertical. A strip of wood is secured to the window frame and extends into the groove in the tile as shown at *a* in Fig. 18. This strip acts as a wind stop and also prevents the frame from falling out of the wall.

A special jamb block is made with full-size blocks as shown at *a*, Fig. 19, and half blocks *b*

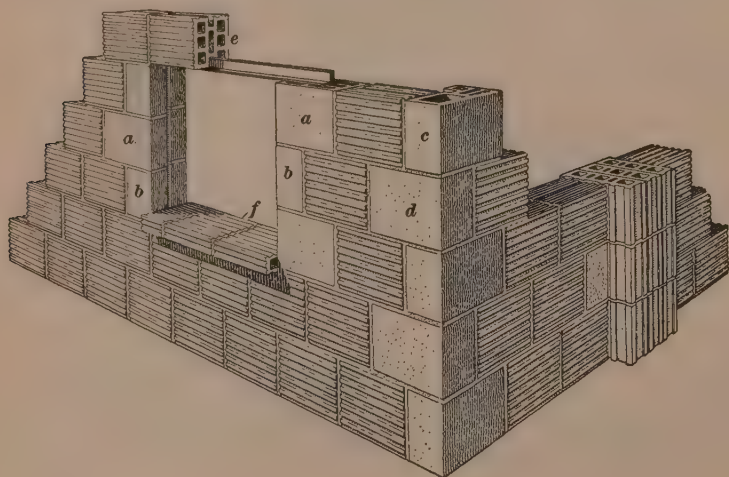


FIG. 19

which are used alternately in the height of the jamb. This block is also shown in plan in Fig. 20 (*a*).

A third kind of jamb block is formed by cutting away a portion of the regular block so as to form a rabbet, as shown in (b), Fig. 20.

37. Sill Tile.—For sills a three-celled block made by cutting a standard **H** block in two, is used as shown in Fig. 18 at *b* and in Fig. 19 at *f*. Brick or stone may also be used as with the regular tile.

38. Corner Blocks.—A special corner block shown at *c*, Fig. 19, is used to complete the corners of walls laid up with **H** tile. The application of this corner block is shown at *e* and *d*.

39. Lintels. Lintels may be made with **H** tile in exactly the same manner as those in the regular block by piling up a sufficient number of blocks on end, inserting steel rods in the cells that will be at the bottom of the lintel when it is in place, and filling these with concrete. Lintels are also formed as shown in Fig. 19 at *e* by placing two steel angles back to back and setting standard tile on top of them.

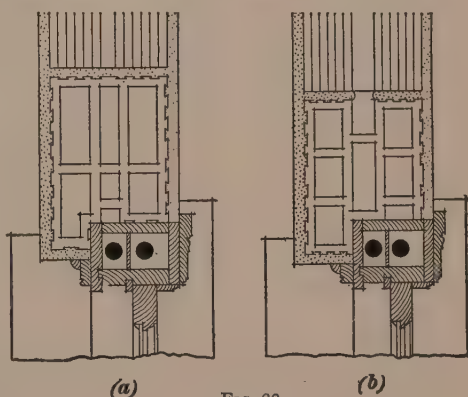


FIG. 20

SPECIAL TILE

40. Backup Tile.—A special type of hollow tile, called *backup* tile, is manufactured for use in backing up brick veneering. By its use a lighter wall can be built than would result if common brick were used for that purpose and one that is sufficiently strong to support the loads that are met with in moderate-sized buildings. Backup tiles are made 5 inches, or two courses of brick, in height, and are either 4 in. $\times$ 12 in.

or 8 in. $\times$ 12 in. in horizontal dimensions, so as to form either a 9-inch or a 13-inch wall with the brick veneering. The use of this form of tile is discussed later on in this Section and is illustrated in Fig. 38.

41. Silo Blocks.—Special hollow-tile blocks manufactured for the purpose of building silos are illustrated in Fig. 21.

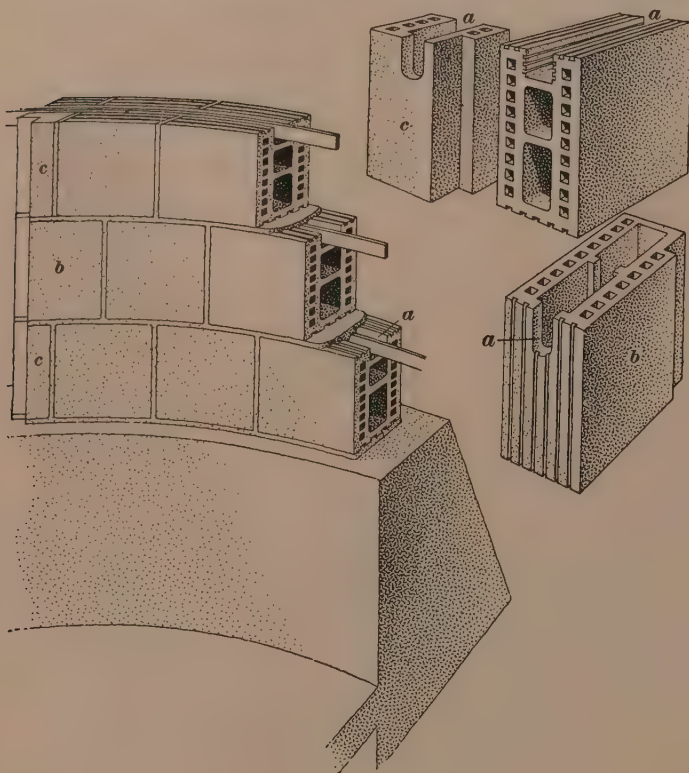


FIG. 21

The blocks are molded to a radius according to the diameter of the silo, and grooves *a* are formed in their upper edges into which iron or steel bands are set. The grooves are then filled with mortar. The purpose of the bands is to prevent the bursting of the silo which might be caused by the pressure of its



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 22

contents. Hollow-tile blocks with which certain standard sizes of silos can be built are kept in stock by manufacturers, and promptness in delivery of the material can be obtained by ordering silos of such sizes.

The blocks are made of vitrified clay, which is fireclay or shale that has been burned until it has become vitrified. They are therefore very durable and are not porous. The size of the regular silo block is 6 inches thick and 12 in. $\times$ 12 in. on the outer face. Where the doors to the silo occur, special jamb tiles *b* and the half jamb tiles *c* are used.

42. Textile.—*Textile* is a form of hollow tile that combines the features of the hollow-tile blocks with those of face brick. The Textile block is a hollow-tile block in which the exposed faces are finished like a rough face brick. A wall built of these blocks has the advantage of being hollow and of having the color and texture of rough face brick where exposed on the outside. The exterior effect of this wall is distinctive, as the faces of the Textile blocks showing in the face of the wall are about three times the size of a standard brick, or about 12 in. $\times$ 5 in. The wall has the appearance of having been built of very large bricks, which gives it a peculiar attractiveness. Fig. 22 shows a charming house, built of Natco Textile blocks, which illustrates the effect of this unit. In contrast with the Textile blocks, the string-course, lintels, sills, and the arch, are built of standard-sized brick, which emphasize the size of the Textile block.

Fig. 23 shows a few of the standard Textile blocks. They are used in practically the same manner as other hollow-tile blocks. In (*a*) is a regular block for use in the body of the wall. The face *a* is finished like the surface of a face brick. The back of the block *b* is grooved to afford a firm grip for plaster. These blocks are placed with the cells in a vertical position. In (*b*) is shown a lintel block made by placing two, three, or more special blocks together end to end, inserting rods *b*, and filling the middle cells *a* with concrete. When the concrete has set, a lintel is formed similar to those made for regular tile and is set in place in a similar manner.

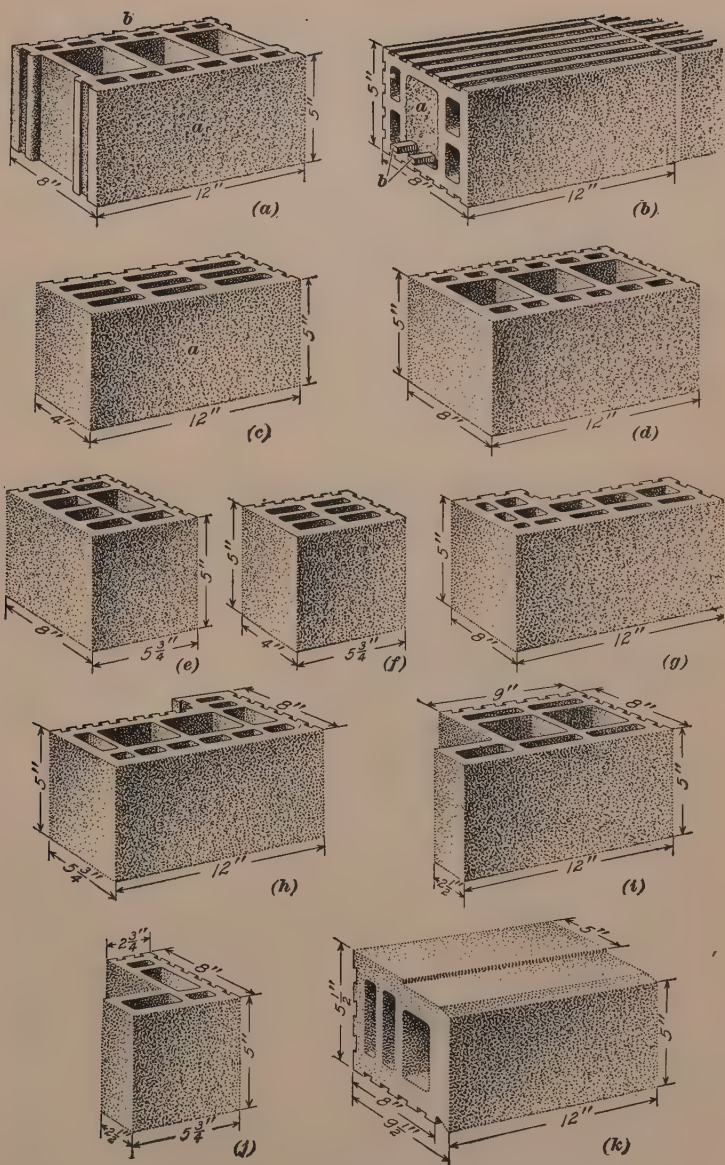


FIG. 23

In (c), (d), (e), and (f) are shown closures used in finishing jambs or sides of other openings in the tile wall that do not require to be rabbeted. Corner blocks are shown at (g) and (h), and jamb tiles at (i) and (j). A sill block is illustrated at (k). These various blocks are used in a similar manner to those already shown in the standard **T**-shaped and **H**-shaped tile. A study of the building shown in Fig. 22 will give a good idea of the method of using Textile blocks.

The shapes of these blocks are similar to those shown in Fig. 5, the difference being in the treatment of the outer face.

SURFACES OF TILE

43. Surface Treatment.—In addition to variations in shape or form, and in density, tile vary in the treatment given to their surfaces. These surfaces are formed according to the purpose for which the tile is to be used.

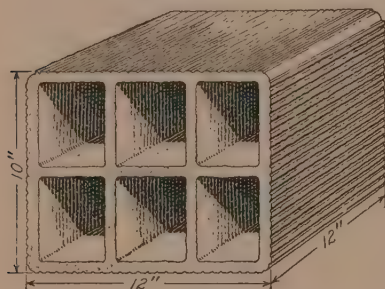


FIG. 24

The principal surfaces made on hollow tile blocks are *smooth*, *scratched*, *scored*, and *special* surfaces.

44. Smooth Surfaces.

Smooth-surfaced tile is, as the term indicates, entirely smooth, and is used most

often in building factories or warehouses where the tile is to be left in its natural state, uncovered by other materials such as stucco or face brick. Tiles are frequently made so as to present a smooth surface on one side only and are scratched or scored on the remaining surfaces. The smooth surface in this case is exposed.

45. Scratched Surface.—Scratched-surface tile is tile having its surface scratched as shown in Fig. 24 so that plaster and stucco will adhere to it more strongly. This surface is used also in walls that are to be faced with brick. Scratched-

surface tile is now so universally manufactured that it has become a standard type.

46. Scored Surface.—The scored surface is an exaggeration of the scratched surface and was designed primarily for walls that were to be plastered, the deep grooves providing an effective mechanical bond between the tile and the plaster. This style of surface is illustrated in Fig. 1. The scorings sometimes are plain rectangular depressions in the surface of the tile, and in other cases are dovetailed. The scored surface has also become a standard one, as it costs little or no more to manufacture than the scratched surface and forms an excellent bond not only for the stucco and plaster but for the mortar joints.

47. Special Surfaces.—Tiles are made with special finishes on the outside and inside for use where they are exposed on the finished surface of buildings and where ordinary smooth tile is not sufficiently attractive in appearance. These finishes are similar to those used on the surfaces of fine face bricks, and are used on the Textile blocks already described.

STRENGTH OF TILE

48. The strength of tile that is of interest to those using it in building is the compressive strength, or strength to resist crushing. This naturally varies with the hardness of the tile. The tile ordinarily used for wall blocks of any shape has a strength of about 5,000 pounds per square inch. This is the ultimate compressive or crushing strength. In practice only a fraction of this strength is estimated upon or employed, generally not more than one-sixth or one-eighth.

49. The building laws of Chicago require that the tile be "hard-burned terra-cotta tile of uniform quality, free from shrinkage cracks, with true beds, and having an ultimate compressive strength of not less than 4,000 pounds per square inch." The strength allowed in actual use is 500 pounds per square inch, or $\frac{1}{8}$ the ultimate compressive strength. These

figures refer to the actual terra-cotta material under compression, without regard to the cells.

50. The New York City building code estimates the compressive strength of tile blocks for the total area of the block, including shell, webs, and cell spaces.

Thus, a block 10 in. $\times$ 12 in. in horizontal section is considered as having a section of 120 square inches, and when tested must show an ultimate crushing strength of not less than 1,200 pounds per square inch when the cells are placed vertically and 300 pounds per square inch when the cells are placed horizontally. Hence the block just mentioned should show an ultimate strength of $120 \times 1,200 = 144,000$ pounds for the entire block, with cells vertical; or $120 \times 300 = 36,000$ pounds with cells horizontal.

The safe carrying capacity allowed by this code is 100 pounds per square inch with cells vertical, and 50 pounds per square inch with cells horizontal.

USES OF HOLLOW TERRA-COTTA TILE

51. Various Uses of Hollow Tile.—Hollow tile in its various forms is used for erecting walls, partitions, piers, columns, floors, and roofs, especially when a fireproof construction is desired. The form of hollow tile here under consideration is that which is designed for building exterior walls to support floors and roofs. Tiles for this purpose are designed with strong vertical webs for supporting such loads, and may be used in conjunction with fireproof floors of terra cotta or used in connection with floors of wooden construction such as those in frame houses.

52. Choice of Tile.—As in the case of other building materials, architects and contractors have their preferences for certain kinds of tile or tile construction, and it is well to be familiar with all the best kinds of tile and their uses so as to be able to choose intelligently among them. Excellent buildings have been erected by using each of the different kinds of tile on the market and by following the methods recommended

by tile manufacturers. The selection depends upon the tile that can be delivered most promptly or which is the best or the cheapest.

FOUNDATIONS OF HOLLOW TILE

53. In many buildings hollow tile is used for the foundation walls. When used for this purpose the tile should be vitrified or glazed, as ordinary hollow tile such as is used for walls above ground will disintegrate in time if placed underground. In this respect it is like common brick, which is not

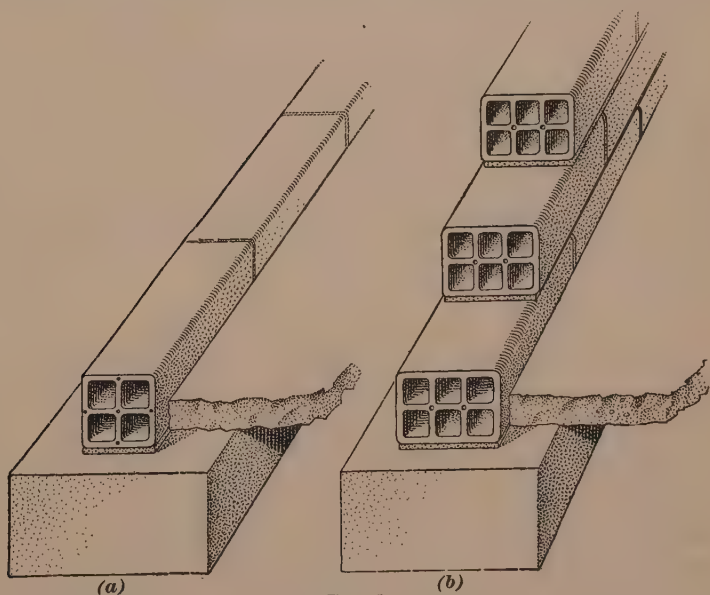


FIG. 25

the best material to use below the surface of the ground unless very hard burned or vitrified.

54. Dense-Tile Foundations.—Dense tile is used for foundations, but when so used it is advisable to protect it from dampness by coating the exterior of the wall with some waterproofing compound such as asphaltum or coal-tar pitch. Another way of protecting this kind of tile is to give the outer

surface of the walls a good coat of Portland cement stucco or plaster as is done in the case of brick foundations. The plaster should be composed of a mixture of 1 part Portland cement and 1 part sand, with not more than $\frac{1}{10}$ of a part of hydrated lime added.

55. Telephone-Conduit Tile for Foundations.

When it is desired to use foundations of hollow tile, ordinary telephone-conduit tile will be found to be very satisfactory both as to endurance and economy. This kind of tile is used for underground conduits by the telephone companies. The tiles are 9 in. $\times$ 9 in. and 9 in. $\times$ 13 in. in cross dimensions, and 18 inches to 36 inches in length. They are illustrated in Fig. 25. The 9" $\times$ 9" tiles laid flat form a wall 9 inches in thickness as shown in (a), and the 9" $\times$ 13" tiles form a 13-inch wall, shown in (b). The larger units contain 6 cells and the smaller units 4 cells. This material will be found strong enough to sustain the ordinary loads of a dwelling house or other small building. Conduit tile is glazed, presenting the same texture as ordinary glazed sewer pipe, and will last for an indefinite length of time underground.

56. Telephone-conduit seconds are conduit tile with slight imperfections in finish, such as blisters or broken edges, and are often slightly warped. They are not satisfactory for the purposes of telephone conduits, but are perfectly useful for building foundation walls below grade. They are also much cheaper than perfect conduits, thus making them economical to use as foundation material.

57. Laying Conduit Foundations.—Telephone-conduit tile should be laid in full beds of cement mortar, and any corners that are broken should be patched with mortar. At the corners of the wall where the openings of the cells appear on the face of the wall, the ends of the cells should be closed up with brickbats and mortar.

58. Building-Code Restrictions.—The building laws of some cities make restrictions as to the use of terra-cotta hollow tile for foundations. Thus, the building code of New

York City specifies that hollow blocks may be used for foundation walls only when the upper walls are of frame or hollow building-block construction; also that the hollow spaces in the blocks shall be filled, as the construction progresses, with concrete consisting of not less than 1 part of cement to 9 parts of aggregate. Other cities require that buildings erected with hollow terra-cotta tile walls shall not be over four stories in height.

59. Other Foundations Used With Hollow Tile.

In many sections of the country, cement concrete, concrete blocks, and stone are of no greater expense than hollow tile and are consequently used for foundations instead of hollow tile, even though the upper walls are to be built of tile.

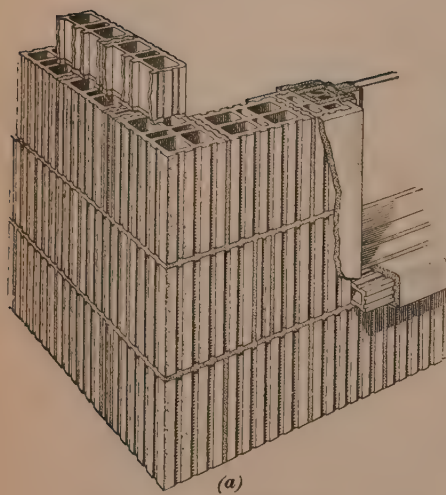
In a house or small building, where the exterior walls above grade are to be 12 inches in thickness, a 12-inch foundation of concrete blocks or of solid concrete is usually sufficient.

Where the upper exterior walls are of 8-inch tile, a 12-inch foundation wall should be used. These thicknesses are for cellar walls that extend 6 or 8 feet into the ground.

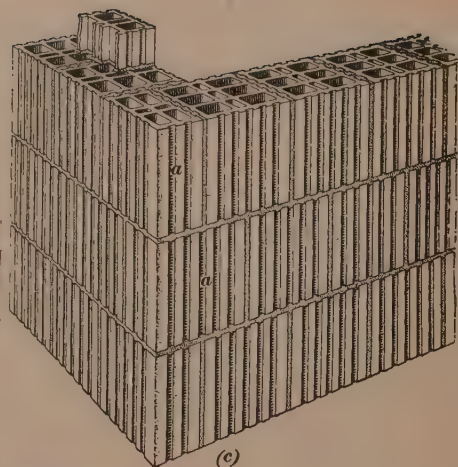
EXTERIOR WALLS OF HOLLOW TILE

WALLS OF REGULAR, OR BOX-SHAPED, TILE

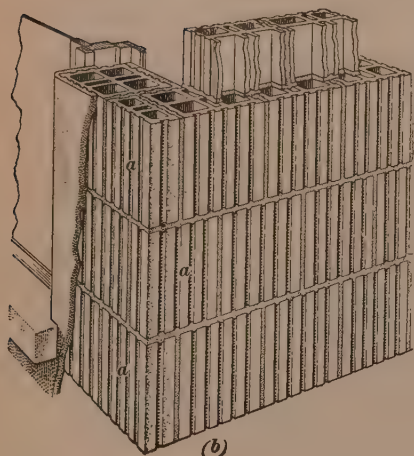
60. Wall Construction.—Illustrations of the individual tiles of box shape used in building walls have been shown in Figs. 1 (*c*), 2, 5, etc. Walls can be built of these blocks in various thicknesses, such as 6 inches, 8 inches, 10 inches, and 12 inches, by making the walls one block in thickness, as illustrated in Fig. 26 (*a*), (*b*), and (*c*). Thicker walls, which, however, are rarely called for, can be formed by combining these units in different ways so as to provide a sufficient bond, as shown in Fig. 26 (*d*). These blocks have a uniform height of 12 inches, but blocks of different sizes can be supplied by the manufacturers if necessary, as where the heights of the different stories of the building do not work out evenly by the use of



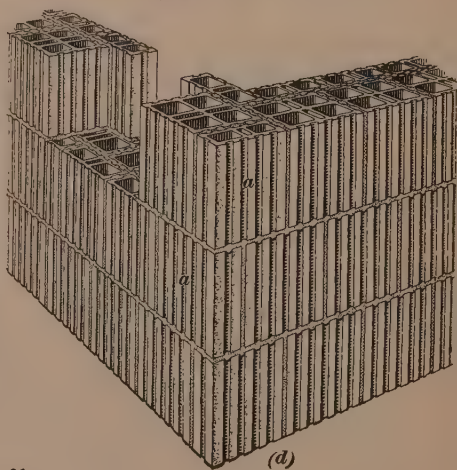
(a)



(c)



(b)



(d)

FIG. 26

blocks 12 inches high. It is an excellent plan when ordering hollow tile to send a set of plans to the manufacturer, who will then be able to ship exactly the right assortment of sizes of blocks.

As a wall is rarely required to have the same thickness for its whole height, the wall in the different stories can be made of different thicknesses. Thus, the cellar wall may be made 12 inches in thickness by using 12-inch blocks, and the first-story walls 8 inches thick by using 8-inch blocks. The second-story walls can be made 6 inches in thickness by using 6-inch blocks.

The New York building code requires that where the walls are reduced in thickness, the blocks on the top course of the

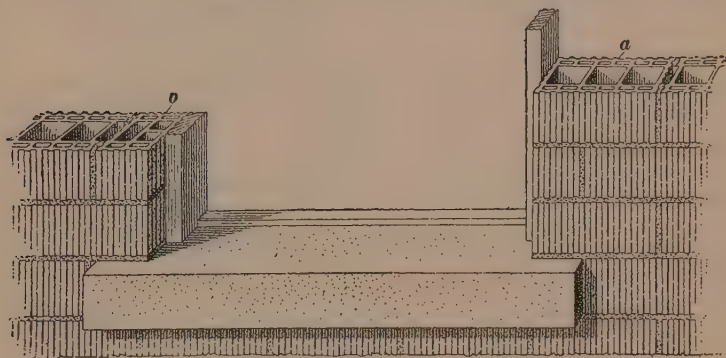


FIG. 27

thicker wall shall be filled solidly with concrete or covered with slabs of hard-burned terra cotta or concrete at least 1 inch in thickness.

61. Blocks of the kind shown in Fig. 5 are placed in a wall in the manner shown in Fig. 27, in which can be seen the construction around a door opening, a closure block being shown at *a* and a half closure block at *b*. A window opening is shown in Fig. 8 with a jamb tile at *a* and a half jamb tile at *b*; the construction of the sills is also shown. In Fig. 10 is shown a treatment for a lintel over a window opening.

62. Bedding in Mortar.—The bedding of tile, that is, the way in which tile blocks are set into the mortar, is a very

important feature of hollow-tile construction. Although different manufacturers claim that their particular forms of hollow tile offer advantages in bedding, bedding is really a matter of good workmanship. Any of the various patterns of tile that have already been described may be well laid if the workman understands the method and desires to do a good job. A good bed of mortar should always be placed beneath the

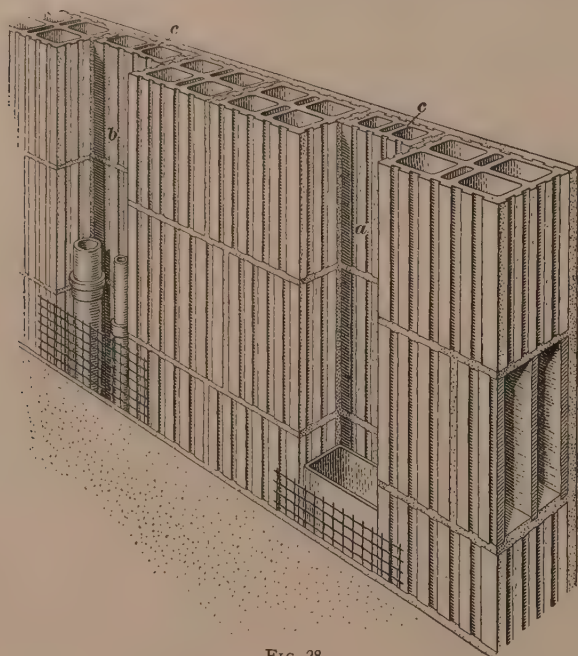
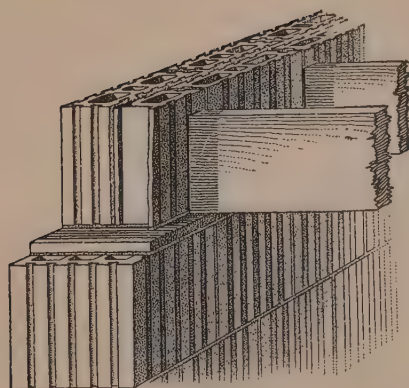


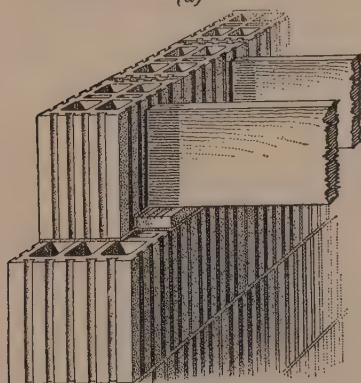
FIG. 28

bearing surfaces and in the vertical joints at both faces, but it is also desirable that the mortar joints should not be continuous through the thickness of the wall.

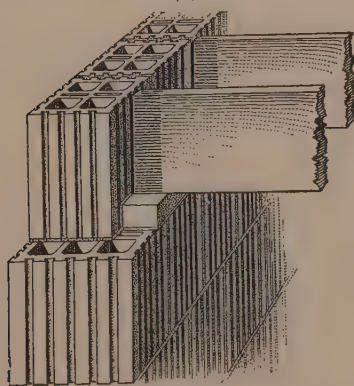
63. Mortar.—The best mortar to use in bedding hollow tile is a mortar made of 1 part Portland cement and 3 parts of clean sand to which $\frac{1}{10}$ part hydrated lime may be added. The mortar should be made stiff enough to adhere readily to the thin edges of the tile.



(a)



(b)



(c)

FIG. 29

64. Cutting Tile.

Terra-cotta tile can easily be broken with a mason's trowel or a hammer in the same manner as brick is broken. It can, therefore, be cut to fit special positions where there are no stock tiles of the proper size and shape on hand.

65. Chases. —

It is generally necessary to accommodate pipes, such as plumbing, heating, and gas pipes, as well as electric-wire conduits, within the thickness of the wall. Chases, or vertical recesses, must therefore be formed either by building recesses in the wall or cutting them in the wall after it is built. One of the advantages claimed for the regular tile is that chases can be cut wherever necessary after the wall is completed. It is not advisable, however, to allow the plumber, the gas-fitter, the heating contractor, and the electrician to hammer out chases in the wall wherever they may choose, hence it is better to build chases into the wall at properly designed points so as to accommodate all

the necessary pipes. Fig. 28 illustrates the method of building chases so that it will not be necessary to ruin the wall with a hammer. The wall at *a* and *b* is made thinner by using thinner blocks *c*, these blocks extending the full width of the chases. Over the chases, strips of wire lath are secured which close the chases entirely and afford a base to receive the plastering. Chase *a* accommodates a heating flue, and chase *b* a soil and a waste pipe.

66. Corner Blocks.—With the regular tile the problem of finishing the corners of a wall is easily solved by the use of regular stock blocks such as shown at *a* in Fig. 26 (*b*), (*c*), and (*d*), and the manufacturers generally send a sufficient quantity of these corner blocks to complete the wall. It is a great advantage to send a set of plans to the manufacturer when ordering, as he will then supply all the special pieces that may be needed to complete the job.

67. Supports for Wooden Floorbeams on Regular Tile.—Where wooden floorbeams are used, they naturally rest on the wall at each end, and the wall should be built so as to provide a suitable bearing for them. As a rule, the wall diminishes in thickness at the level of the floorbeams so that a shelf is formed by the projection of the lower wall beyond the upper wall, and upon this the floorbeams generally rest, as shown in Fig. 29. Where the difference in the thickness of these walls is 4 inches, a sufficient bearing is afforded for the average wooden joist, and flat tiles as in (*a*) and (*b*) or a row of bricks as in (*c*) is laid on top of the 4-inch projection. Upon these tiles or bricks the ends of the joists are placed.

Where there is a difference of only 2 inches in the thickness of the walls or where the walls of both stories are carried up at the same thickness, it becomes necessary to extend the ends of the joists into the upper-story walls so as to obtain at least a 4-inch bearing. This condition calls for a special arrangement of the tiles at the level of the joists, as illustrated in Fig. 30.

In this figure the joists are shown bearing upon a 1-inch flat slab *a* that is carried entirely through the wall. This affords a

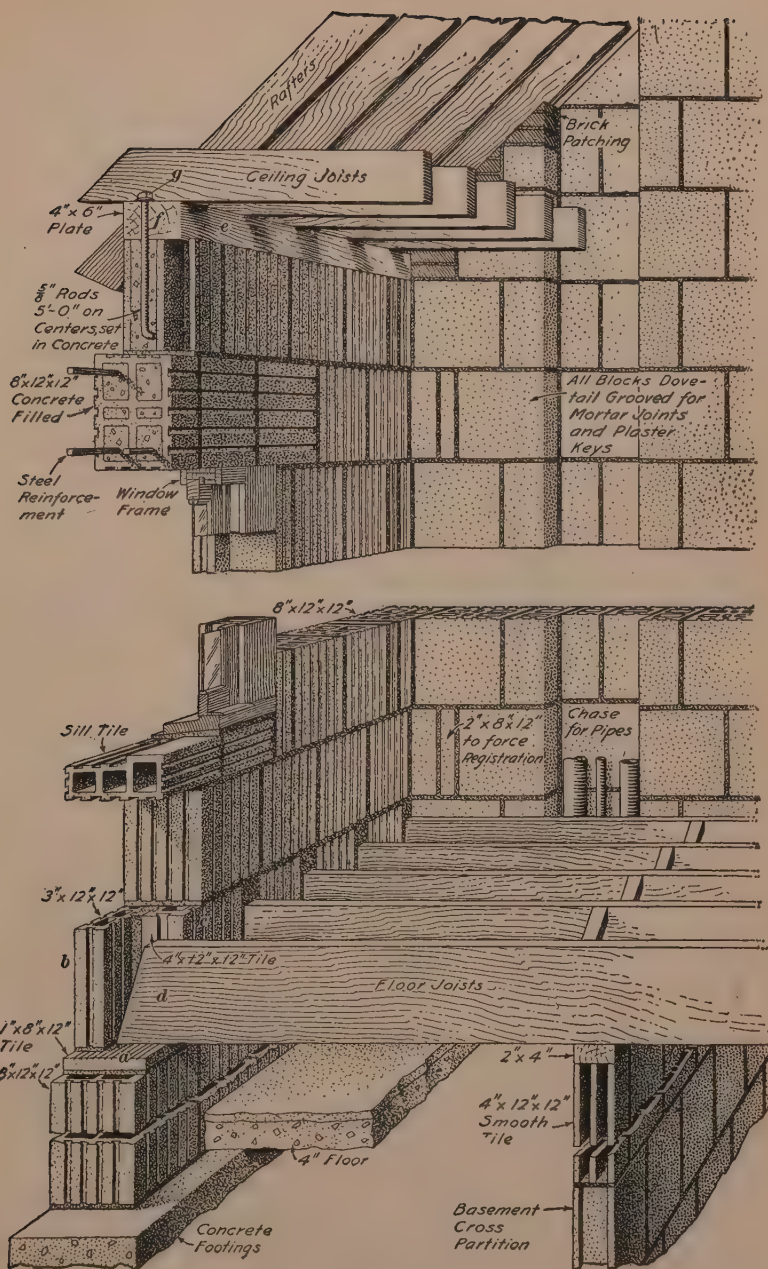


FIG. 30

flat bearing for the ends of the joists. Between the ends of the joists and the outside of the wall a row of thinner wall tiles *b* is placed and a second row of tiles *c* is placed between the beams. These two rows together form a base upon which the wall above rests.

68. A method that is sometimes used for supporting wooden floor joists is shown in Fig. 31 in which the joists are suspended by means of steel joist hangers *a*, which are in turn supported upon flat 1-inch slabs *b*. An advantage in this method is that the trouble of fitting the tile around the ends of the joists is avoided.

69. Anchoring Wooden Floor Joists.—The ends of joists when projecting into a tile wall should be cut with a *fire cut*, as shown at *d*, Fig. 30. This cut is so called because it permits the beam to fall out without injuring the wall if the timber should be burned off.

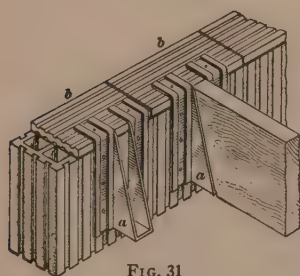


FIG. 31

Every fourth joist should be anchored to the wall by means of a wrought-iron rod, strap, or *dog*, driven into the top of the joists and built into the masonry. The purpose of these anchors is to tie the floors to the walls, and thus give greater stability to the building. Walls parallel to floor joists should be anchored by metal straps nailed to three or four joists and turned up into the wall.

70. Supporting Fireproof Floors on Regular Tile. The several forms of fireproof flooring used in connection with hollow-tile construction will be described and illustrated later, but the provision that must be made in the walls to receive the floors will be described at this point.

The floor systems mostly used in connection with hollow-tile construction are the flat concrete slab, the combination floor of hollow tile and reinforced concrete, the Johnson system, and the New York wire-truss system; and they all require that the

bearing walls supporting them have a flat tile placed over the ends of the cells to receive the floors. These floors extend to within 4 inches of the outside of the tile wall and a 3-inch facing tile is placed as shown at *a* in Fig. 32. At *b* is shown the flat bearing tile on which rests the floor system *c*, the weight of which is thus transferred to the bearing wall *d*. The upper-story wall *e* is started directly on the floor construction, as shown in the figure. In Fig. 33 the floor construction is shown resting on the lintel over an opening.

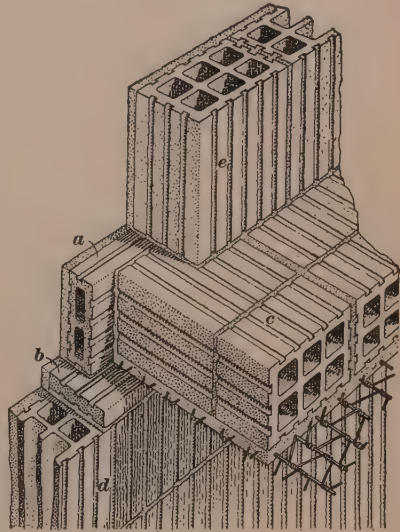


FIG. 32

71. Concentrated Supports.—In the floor

systems that have been mentioned the load is distributed over the bearing walls quite uniformly and does not necessarily bring any concentrated load on any particular point in the wall. Where steel girders are used, concentrated loads occur at the bearings of these girders, and the wall must be especially strengthened at these points. This is done by filling the cells of the tile with concrete for two or three courses below the bearing of the beam, or even down to the footings, to form a solid masonry pier under the load. Where the cells of the tile are in a horizontal position, a brick pier is sometimes built extending down

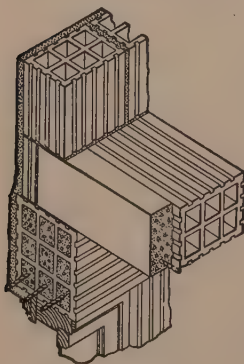


FIG. 33

for several tile courses and spreading out toward its lower part. This distributes the load over a large area of wall below.

As in the case of the non-fireproof construction, flat roofs of fireproof construction are similar to the floors in their design.

For pitched roofs of fireproof construction the same principles are used as in non-fireproof construction. As shown in Fig. 34, a metal plate *a* is anchored to the wall by bolts built into the wall and extending up through the plate so that a nut may be screwed on the top of the bolt to hold the plate in position. The rafters, which are generally I beams, are anchored to the plate as shown at *b*, and T irons *c* and an angle iron *f* are secured to the rafters at such a distance apart as to take the

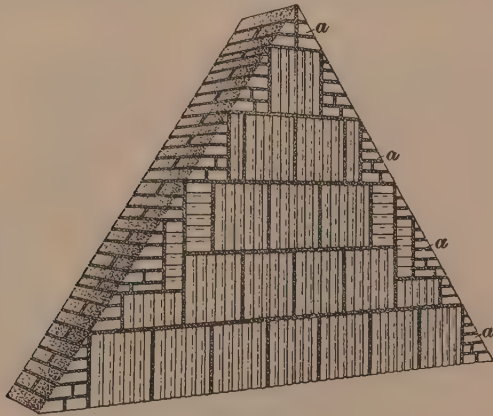


FIG. 35

tile *d* called book tile. A layer of cinder concrete *e* is then placed over the book tile and the roofing is nailed to it.

74. Pitched roofs may be made of the combination construction used for floors, which is described later on. This construction is exactly the same as a floor set on a slope. It is an expensive construction and is used only on elaborate work.

75. Finishing Gables.—In building gable walls of hollow tile it will be found wasteful to cut the blocks to a triangular shape to fill in the spaces *a*, Fig. 35. These triangles are therefore generally filled with brickwork as shown in the figure.

WALLS OF H TILE

76. The shapes of **H** tile have already been shown. The sizes are 12 in. $\times$ 8 $\frac{1}{4}$ in. horizontally, and 5 $\frac{1}{8}$ in., 7 $\frac{5}{8}$ in., and 10 $\frac{1}{4}$ in. vertically. The vertical heights, plus the thickness of one mortar joint, correspond to two, three, and four courses of common brick with the necessary mortar joints. A single block makes a wall 8 $\frac{1}{4}$ inches thick. When a 13-inch wall is required, the thickness is made of one 8 $\frac{1}{4}$ -inch tile and a half tile. These half tiles are made and carried in stock but may also be obtained by simply splitting the whole tile. The half tiles in such a wall are placed on the outside and the inside of the wall in alternate

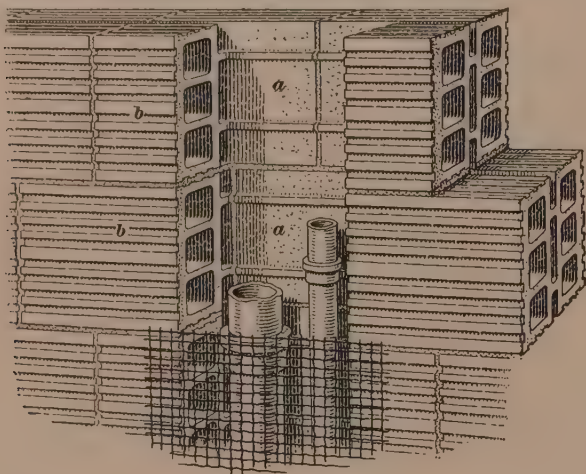


FIG. 36

courses as shown in (b) in Fig. 17. It will be noticed in this figure that the horizontal bed of mortar is broken into 3 parts so that it is not continuous through the wall.

77. Supporting Floors on H Tile.—Floor joists of wood are supported directly upon the upper surface of the blocks. The joists extend into the wall so as to bear upon two lines of vertical webs. The spaces between the ends of the joists are filled with 4 $\frac{1}{8}$ -inch tiles, which are the standard blocks split in two. Fireproof floors are supported in the

same manner, but such floors must be carried to within about 4 inches of the outer face of the wall so as to have as large a bearing as possible.

78. Supporting Plates.—The plates for supporting the lower ends of roof rafters on **H**-tile walls are secured in the same manner as on brick walls or walls of regular tile. Bolts are built into the wall so as to extend down about 16 or 18 inches and also to project through the top of the plate and receive a nut.

79. Finishing Gable Walls.—The triangular spaces in gable walls are finished in the same manner as for regular tile, as shown in Fig. 35 at *a*.

80. Chases.—Chases may be formed by the use of blocks of half thickness, as at *a*, Fig. 36, and bonding them into the full-thickness blocks *b*.

WALLS OF T-SHAPED TILE

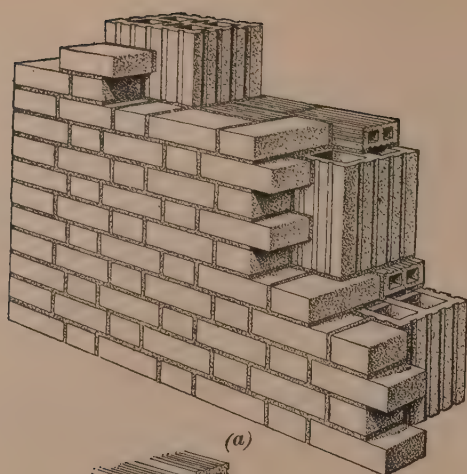
81. T-shaped tiles are laid up in the wall as shown in Figs. 12, 13, 14, 15, and 16. In the 16-inch wall in Fig. 12 (*c*), a special tile *f* is required to complete the bond properly. Walls of other customary thicknesses, however, can be built with the regular **T**-shaped tile. A solid block of special shape is required to start the wall at the bottom, as shown at *e*, Fig. 12 (*a*), (*b*), and (*c*).

Jamb blocks are placed on end at each side of the opening, and must be securely anchored to the wall as shown in Fig. 13. Corner blocks of two different heights, as shown in Fig. 13 at *d* and *e*, are required to finish the corners properly. Chases are built as shown in Fig. 15.

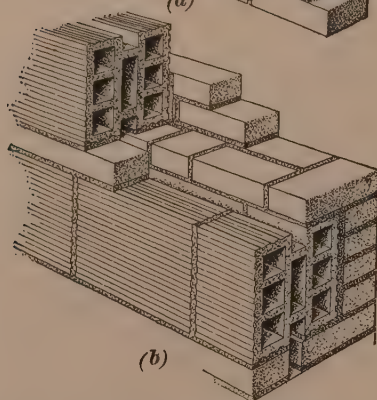
Floors and roof plates are supported in the same general way as is done in **H**-tile walls.

VENEERED WALLS

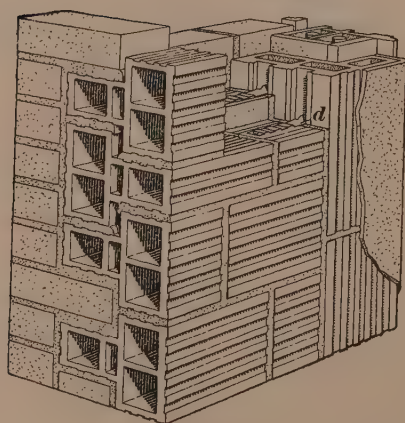
82. By veneering the outer surface of a hollow-tile wall with brick, the advantages in appearance due to the brick facing, and of the air spaces and lightness due to the hollow-tile construction, are both secured.



(a)



(b)



(c)

FIG. 37

The principal problem in constructing a brick-veneered wall is the bonding of the brick face securely to the tile backing. The various types of tile mentioned are designed so that this bonding may be readily accomplished. In Fig. 37 are shown the methods of tying or bonding the brickwork to the tile work

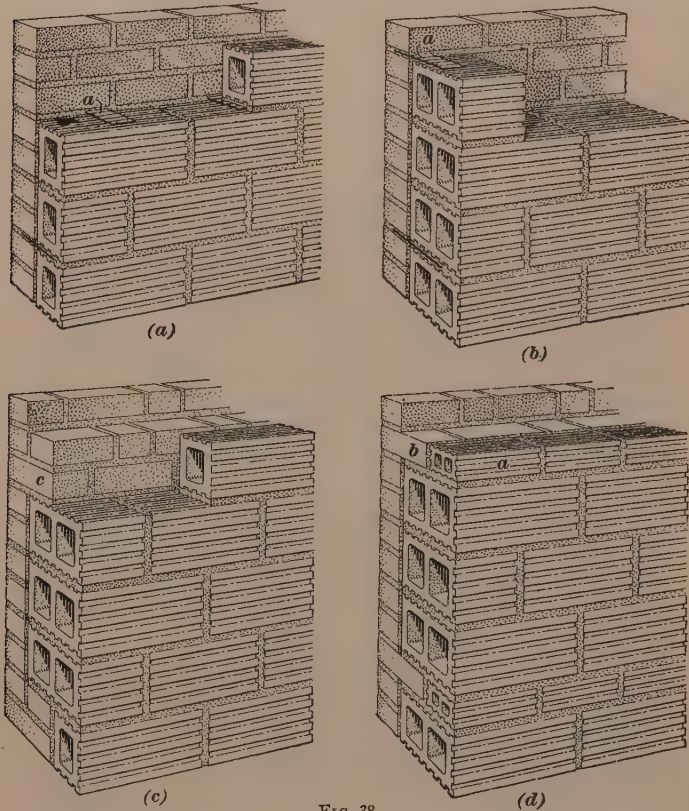


FIG. 38

of the three types already described. In (a) is shown the method used with the regular tile; in (b) and (c), with H tile and T tile. When it is desired to show no headers in the brick facing it is necessary to tie it to the tile with metal ties, in the manner shown at *a* in Fig. 38 (a) and (b). When brick-veneered walls are used, it is a frequent custom to use solid

stone sills and lintels for the window openings as well as stone string-courses, as is done in a brick building with solid walls.

83. Backup Tile.—A special type of hollow tile, called *backup* tile, is manufactured for use in backing up brick veneering. By using this tile a very light and economical wall can be built. The *backup* tiles are made with one face smooth for use in places where it is not desired to plaster the interior face of the wall. These tile are sometimes called “*Jumbo*” brick.

Where the brickwork shows only stretchers on the face, the bond to the backing is made by using metal wall ties as shown



FIG. 39

at *a* in (a) and (b), Fig. 38. Where, however, heading courses of brick are used, headers can extend into the wall as shown in (c) and (d). By using hollow-tile brick, as shown at *a* in (d), only one course of face brick is needed in forming the bond instead of two courses as shown in (c).

Fig. 39 illustrates a method of laying up a wall consisting of a brick-veneered face, backup-tile backing, and metal ties.

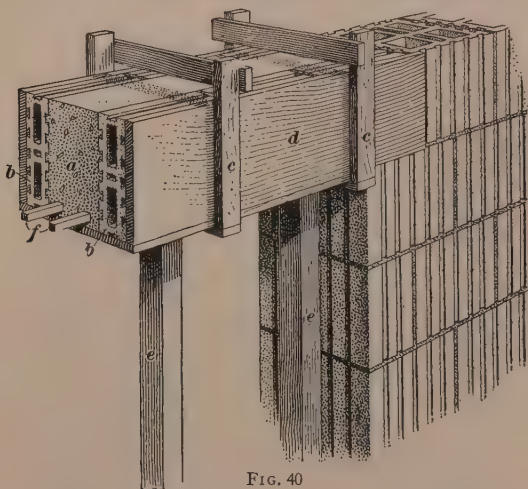


FIG. 40

Two of these ties are shown projecting from the back of the face-brick veneering between the hands of the two men.

OPENINGS IN WALLS

84. Openings.—Openings in walls are generally for doors and windows. The blocks that are used around such openings, such as lintels, jambs, and sills, have been illustrated.

The lintels are the only blocks that vary with the width of the opening. Lintels have been shown for spans of not over 5 feet. For lintels of a greater span than 5 feet, reinforced concrete or steel must be depended upon.

In Fig. 40 is shown a lintel which consists of a reinforced-concrete beam *a* faced with hollow tile *b*. The concrete beam is designed to carry all the load coming from the wall above the opening as well as from floor-beams that may rest on this wall.

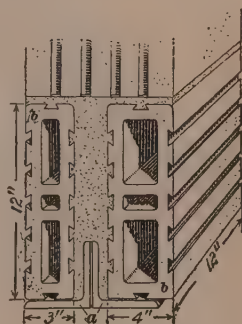


FIG. 41

The lintel is faced with thin blocks of hollow tile, which afford a better surface for stucco and plaster than the concrete surface would. These tiles adhere strongly to the concrete lintel, as the concrete flows into the dovetail grooves when the lintel is cast.

A lintel of this type is generally cast in position. The lintel shown in this figure is made in a wooden form, as shown at *d*. This form must be strongly supported by the struts *e*, and its sides must be braced as shown at *c*, so that they will not spread

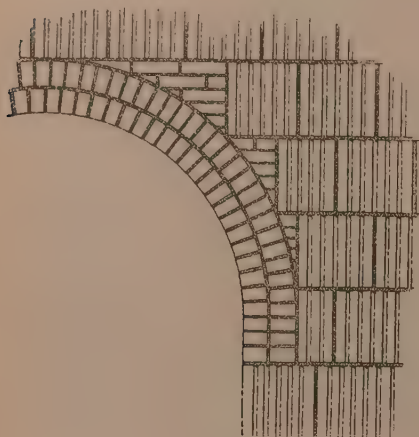


FIG. 42

apart when the concrete is cast in place. The tiles *b* are first placed in position and the rods *f* are set so that they will be about 1 inch above the bottom of the lintel. The concrete is then poured into the space *a* and allowed to set for a few days until it has attained considerable strength, when the forms may be removed.

A lintel that requires no forms and that will be ready to bear the load within a day or so is shown in Fig. 41. This lintel is virtually a steel lintel formed of two angles *a*, upon which terra-cotta blocks *b* are set, and concrete or cement mortar is filled in between them. The strength of this lintel is that of the two steel angles.

85. Arched Openings.—Arched openings in hollow-tile walls are made by using either plain bricks in the form of row-lock arches as shown in Fig. 42, or by using hollow-tile blocks as voussoirs, or arch blocks, as shown in Figs. 43 and 44.

In the arch shown in Fig. 42 the rectangular tile blocks are not cut to fit the triangular spaces, as brickwork is used to fill up these spaces, as shown.

COLUMNS AND PIERS

86. Columns.—Many designs for hollow-tile houses require round columns in such places as the front entrance or



FIG. 43

on porches. Manufacturers make a *radius tile*, or tile molded with a curved surface, such as shown at *a* in Fig. 45, which can be laid up to form cylindrical columns of different diam-

eters. When these columns are expected to support an extra-heavy weight the interior of the cylinder is filled in solidly with concrete *b*, which is sometimes reinforced with rods or bars *c*.



FIG. 44

Columns of this description are practically reinforced-concrete columns and will support loads in proportion to the diameters of the concrete cores. The enclosing tile is generally scored on the outside so as to hold a finishing coat of stucco.

87. Piers.—Piers, as shown in Fig. 46, can be built of stock-size blocks, which must be set up so as to break joints in

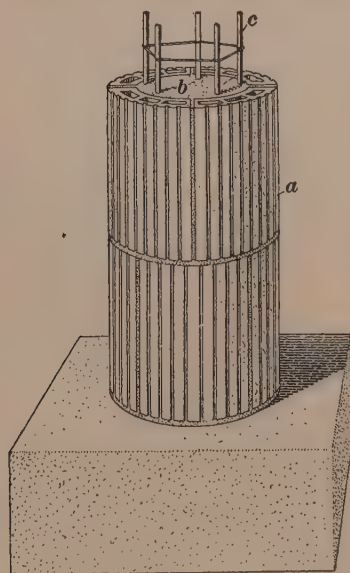


FIG. 45

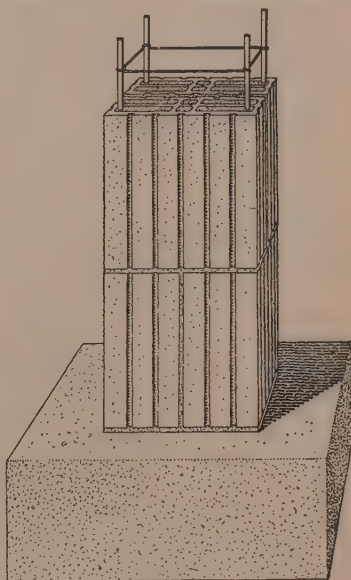


FIG. 46

alternate courses. These piers should be filled with concrete when supporting heavy loads. Reinforcing rods may be added as shown where greater strength is required.

ATTACHING FURRING, TRIM, ETC. TO WALLS

88. Use of Wooden Laths.—Many architects prefer to fur the interiors of all external walls of hollow-tile construction, as this provides space between the tiles and the plaster for gas and water pipes and electric conduits. It also affords a means of preventing cold striking through the walls to the plaster and causing moisture to condense on the face of the plaster. When the use of furring is contemplated, wooden laths are often built into the horizontal joints between the tiles at proper distances apart to afford nailing for the furring strips. This is illustrated in Fig. 47 at *a*,

89. Metal Wall Plugs.—Another good method of providing nailing for wooden furring is to use metal wall plugs, shown at *b* in Fig. 47. These plugs are small bent corrugated plates of metal that are set in the mortar joints while the wall is being built, and receive and hold nails driven into them through the furring strips as shown in the illustration.

90. Self-Clinching Nails.—Self-clinching nails may also be used for fastening wood to tile. These nails, shown in Fig. 47 at *c*, are driven through the furring strips and also

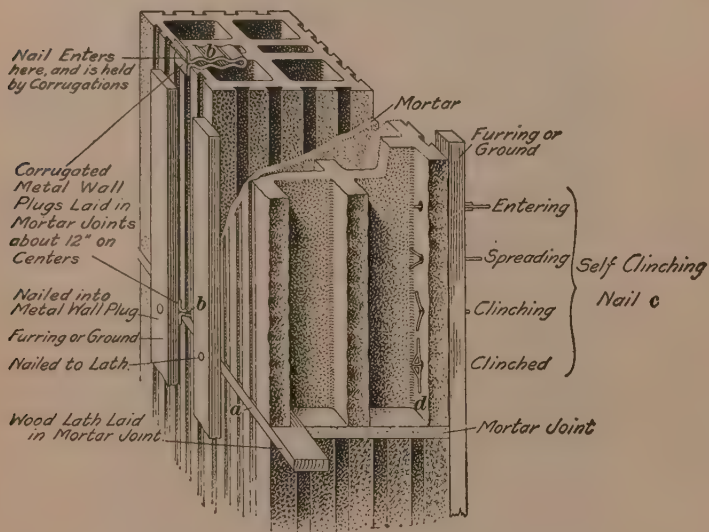


FIG. 47

through the shell of the tile, in which holes have previously been punched. The last blows of the hammer cause the nails to spread and clinch on the back of the shell as shown at *d*. An enlarged view of a self-clinching nail is shown in Fig. 48. In (*a*) the nail is shown closed and ready to drive, in (*b*) the nail is shown driven through the furring and tile and clinched.

91. Toggle-bolts are shown in Fig. 49. These bolts have heads *a* that are hinged to the bolts. A hole is made in the tile of sufficient size to allow the head to enter as shown

in (b). When the head has passed through the hole the head is turned on the hinge so that it stands at right angles to the hole. The threaded shank of the bolt extends through a hole bored through the furring and is fitted with a nut which is screwed up and holds the furring firmly in place. In (c) is a view of a toggle-bolt in position.

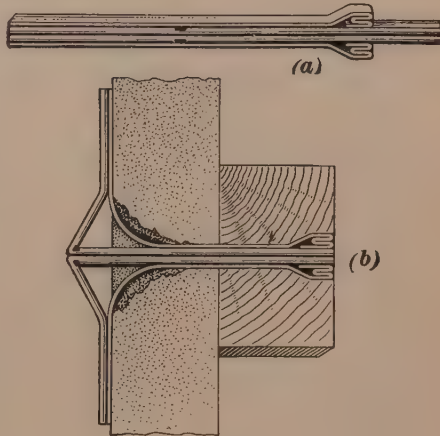


FIG. 48

92. Ankyra Ankor Bolts.—A useful form of expansion bolt for use in securing furring, grounds, etc., to hollow-tile walls is known as the Ankyra Ankor bolt and is illustrated in Fig. 50. In (a) is shown the bolt, which consists

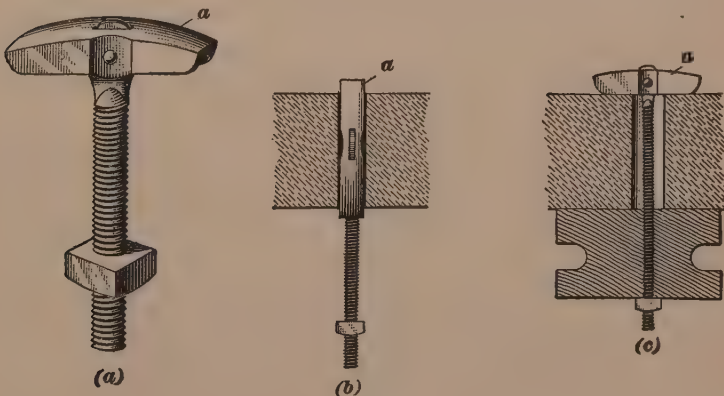


FIG. 49

of a divided shell *a*, a collar *b* with a projecting portion or lug *c*, and a collar *d* which is threaded to receive an ordinary wood screw such as *e e*. In (b) the bolt is shown drawn up so that the shell *a* expands in three directions. In (c) the bolt is

shown under various conditions. At *a* is a hole that is punched through the terra-cotta tile *b* into which the shell of the bolt *c*

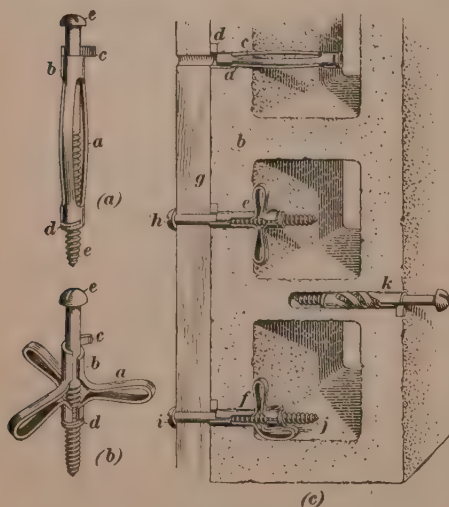


FIG. 50

has been driven. A slight tap of the hammer will drive the lug *d* into the tile and the lug will keep the shell of the bolt from revolving or slipping into the hole. The shell is then pulled together as shown at *e* and *f* by means of a device inserted into it. This establishes the shell firmly in place and it is ready to receive the screw that is to hold the furring in place as shown at

h and *i*. The tighter the screw is turned the firmer the hold this bolt will take. The position that a bolt will take in a corner is shown at *j* and the method of holding in solid terra cotta is illustrated at *k*.

93. Grounds to which trim, base, wainscoting, picture moldings, etc. can be nailed can be secured to the tile walls in the same way as furring strips.

PARTITIONS OF HOLLOW TILE

94. Partitions.—Interior partitions of hollow tile are usually made thinner than outside walls, because they do not have to resist the weather and frequently they carry only light loads. Interior partitions in ordinary houses are built of 3-inch, 4-inch, or 6-inch blocks. In a fireproof house, where the weight of fireproof floors must be taken into account, the main bearing partitions are sometimes made of 8-inch blocks.

It is necessary that tile partitions be rigidly supported. They must therefore rest upon solid walls or partitions beneath or upon steel beams. When fireproof floors are used, partitions in the upper stories may be set on these floors slightly to one side of the partitions below, or, in other words, need not be set directly above them.

The blocks used for partitions are those used in fireproofing and are described in the Section entitled *Fireproofing of Buildings*.

FLOOR SYSTEMS

95. The floor systems used in connection with hollow-tile walls are not peculiar to them. In fact any of the flooring systems used in other buildings can be used equally well in buildings having hollow-tile walls. As these floor systems are described elsewhere, it would be repetition to describe them extensively here, consequently a merely superficial description will be given.

96. Non-fireproof floors, such as are used in ordinary frame structures, are most frequently used in tile buildings, but are not to be recommended, on account of their inflammable nature.

97. Hollow-Tile Fireproof Floors.—While any type of fireproof floor can be used in connection with hollow-tile walls, the most natural fireproof floor to use is one that is composed of the same material as the wall; that is, hollow terra-cotta tile.

Two systems that make use of plain hollow-tile blocks as an essential part of their structure are the *combination floor system* and the *Johnson system*. These types of floors are the ones most used in dwellings. In larger buildings the flat-arch floor systems, the segmental-arch system, and the wire-truss system are employed. As these last-mentioned systems are described in the Section entitled *Fireproofing of Buildings*, they will not be described here.

98. The Combination Floor.—What is generally known as the *combination floor* is frequently employed for

ordinary spans. This floor consists of what may be described as reinforced-concrete beams with hollow tile held between them.

In building such a floor, planks are first erected as a form or temporary support for the entire floor. Upon this form or platform, sometimes called *centering*, the tiles are laid in rows about 16 inches on centers with the cells lying in the direction of the rows. After the tiles are all laid, reinforcing rods are placed at the bottoms of the spaces between the rows and

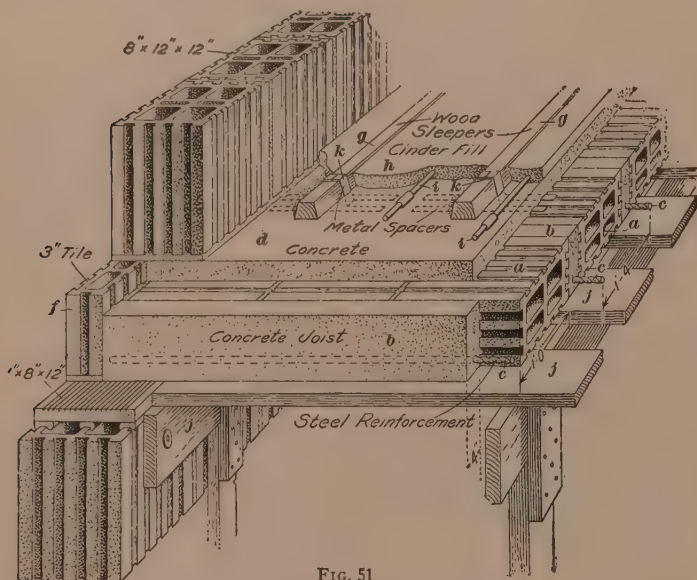
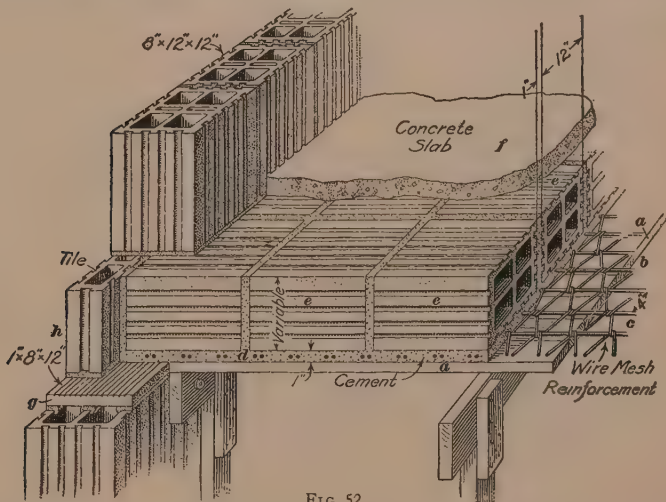


FIG. 51

concrete is poured into the spaces and over the top of the entire construction to a thickness of about 2 inches, as shown in Fig. 51. This figure shows the hollow tile of the floor at *a*, the reinforced beams at *b*, the reinforcing rods at *c*, and the 2-inch layer of concrete over the top of the tile at *d*. The rods *c* are kept up above the centering about $\frac{3}{4}$ inch, so as to be entirely embedded in concrete and thus protected from rusting and fire. The entire construction rests upon 1-inch flat tile slabs set on the wall, and is faced on the outside of the wall

with 3-inch facing tile *f*. The upper wall rests directly upon this floor construction.

On top of the floor construction, wooden cleats, or sleepers, *g* are laid about 12 inches on centers to afford nailing for the wooden floors. These sleepers are made from 2"×4" stuff and are beveled on both sides. They are secured in place by the use of sheet-metal spacers *k*, that are held down by the weight of the concrete that is placed upon them, and are nailed to the sleepers. It is customary to fill in between these sleepers with cinder concrete *h*. After this fill has become thoroughly



In erecting the Johnson floor, a centering *a*, Fig. 52, consisting of a floor made of matched boarding is built, and on this platform a network of steel reinforcement *b* is laid, usually consisting of a heavy metal fabric reinforced by steel reinforcing bars *c*, placed at intervals of 5 or 6 inches. This metal is then embedded in a layer of cement mortar about 1 inch thick. On top of this layer, tile blocks *e* are laid in rows as in combination floors, but about 1 inch apart. The size of the tile varies according to the span and the load.

Concrete is poured into the spaces between the rows of blocks and, where the loads are ordinary, filling these spaces is sufficient. When the loads are heavy a concrete slab *f*,

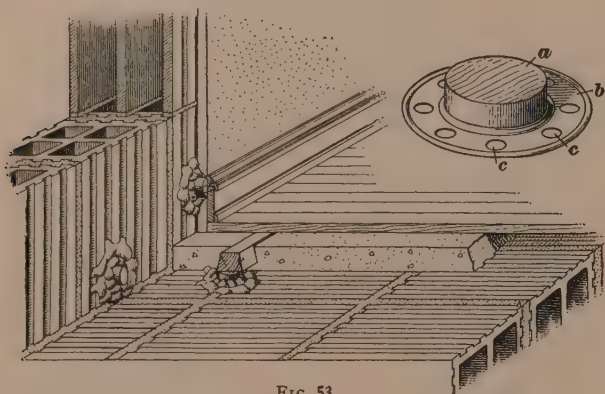


FIG. 53

about 2 inches in thickness, is poured over the tops of the blocks at the same time. As in the case of the combination floor, this floor rests on a flat slab *g* on the wall and is faced on the outside of the wall with a 3-inch facing tile *h*. The details of placing sleepers, pipes, and the finished floors are the same as in the combination floor.

100. Securing Sleepers, or Cleats, to the Floor Construction.—To secure wooden floor sleepers, or cleats, to which the floor is nailed, there are several appliances. One of these consists of small galvanized-iron hooks each of which has a flat end that is embedded in the cinder concrete and a sharp end that is driven into the cleat when the cleat is in its

proper position. These hooks are spaced about 12 inches on centers and hold the cleats firmly in position. Other methods consist of metal strips that are embedded in the cinder concrete and have projecting ends that can be bent over the cleats and nailed to them as shown at *k* in Fig. 51.

A very efficient and ingenious method of attaching furring, sleepers, and grounds to hollow tile is by the use of what are known as *spot grounds*, illustrated in Fig. 53. These grounds consist of a disk of wood *a*, firmly attached to a circular flange of sheet metal *b*, which is perforated with holes *c*. The grounds are secured to the terra-cotta surface by the use of plaster of Paris or Portland cement. Before the plaster has set, the grounds are brought to the correct level so that the furring or sleepers when nailed to the grounds will be straight and level. When the plaster or cement has hardened they afford firm spots into which nails may be driven.

ROOF CONSTRUCTION

101. As has been stated, fireproof roofs are not generally placed on hollow-tile buildings. When, however, they are used they are similar in construction to floors or fireproof roof constructions that are described elsewhere.

STUCCO FINISH

102. Need of Finish on Tile.—The natural appearance of a tile wall is not very attractive or artistic unless the tile is made with special surfaces, as in the case of Textile blocks. Tile walls are, therefore, generally covered with a stucco, or plaster, which is applied so as to produce artistic effects.

COMPOSITION OF STUCCO

103. Stucco.—What is known as *stucco* is in reality a cement plaster formed of Portland cement, sand, lime, and water, and applied in the same manner as ordinary wall plaster.

104. Ingredients of Stucco.—The Portland cement may be of any of the standard brands such as the Atlas, Alpha, Lehigh, Universal, or Vulcanite. These cements are generally of a gray or mouse color and may be used in the first coats of stucco and in the finishing coat when this gray tint is satisfactory.

Portland cement is also made of a pure white color. Such cement is used when it is desired to produce a pure white color in the finishing coat; also when light tints of various colors are required. The white cement merely lightens the tint of any coloring material that may be added to the stucco without destroying the quality of the color. When delicate tints or tones of pink, yellow, or brown are sought, white Portland cement should be used.

105. The **sand** should be clean, free from loam, salt, and other impurities. It should consist of coarse and fine particles mixed together rather than of uniform-sized grains. Ordinary sand possesses a yellowish or reddish color which affects the color of the stucco. When used with a gray Portland cement it results in a gray or mouse-colored stucco. The colors of

the gray cement and the sand greatly modify the effect of mortar colors that are used in coloring stucco and make it impossible to obtain light tints such as buffs, pinks, yellows, etc.

In order to obtain delicate light colors in the stucco, white cement should be used and also *white sand*. Instead of white sand, pulverized marble is sometimes used. This is called *marble dust*. By the use of white cement and white sand or marble dust, light pure tints can be obtained by using small quantities of mortar colors.

With the use of white cement and sand as a base, delicate and desirable tints can be produced by adding **crushed stone** of various colors to the stucco. The stones used for this purpose are marbles, granites, and other crystalline rocks, as well as pebbles that possess high colors. These colored particles of stone should show in the face of the stucco in order to produce a color effect in the wall.

106. The best form of **lime** to use is hydrated lime, which is a carefully and scientifically slaked lime and is in the form of a fine white powder. It can be mixed dry with cement and sand, and when all these ingredients are thoroughly mixed the water can be added.

Lump lime is sometimes used instead of hydrated lime, but must be carefully slaked, strained, and allowed to stand for a week or ten days before using.

107. The **water** used in mixing the stucco should be free from alkalies, acids, and vegetable matter, as these materials may interfere with the setting of the cement.

108. Mortar Colors.—The coloring materials used in tinting stucco are known as *mortar colors*, and are the same as are generally used in coloring mortar used in brick and stone masonry. The best of these mortar colors are sold in pulp form so that they will mix readily with the mortar or stucco. When mixing different batches of colored mortar for the same job, great care should be taken that the same fixed amount of colors is used for a given amount of mortar or stucco. If this is not done the different batches of mortar will show different

tints on the surface of the wall. Only the best and most permanent colors should be used or else the colors will fade or disappear in time.

APPLICATION OF STUCCO

109. The First, or Scratch, Coat.—When the hollow-tile walls of the building have been finished and the roof is in place, the building is ready to be *stuccoed*. As with any plastering, the weather conditions should be suitable; that is, neither too hot nor too cold.

Scaffolds should be erected entirely around the building, after which the mechanics can put on the first coat of stucco,



FIG. 54

which should be pushed firmly against the tile so that it will flow into the grooves and make a secure bond. Deep-grooved tile is best for use in work that is to be stuccoed, as the grooves provide a good mechanical bond between the stucco and the tile. When glazed tile is used, the dovetail scorings on the tile are the only means of holding the plaster to the tile, as the

glazed surface affords no bond whatever. In semiporous tile the slight absorptive power of the surface of the tile affords a grip for the stucco.

When the first coat has hardened slightly it should be *scratched*. This is usually done with a piece of board that has its edge notched, as shown in Fig. 54. This scratching gives a rough surface to which the second coat will adhere. The first coat should thoroughly fill all the grooves in the face of the tile and cover the tile with a thickness of about $\frac{1}{4}$ inch.

110. The Second Coat.—The second coat is applied when the first coat has set but before it has dried. It is when putting on this coat that the surface of the plastering is made true and smooth. This is done by using long straightedges at the corners of the building and around the openings and working the stucco to an even surface between them, all hollow spaces being filled in and projecting ones cut down. All this straightening is done while putting on this second coat.

111. The Third Coat.—After the second coat has set, but before it has dried, the third, or *finishing*, coat is put on. This third coat is the one that is visible to the eye and gives character to the appearance of the building. This character or effect is caused by the color and the texture of the finished surface. By the use of various materials and processes a large variety both of color and texture can be obtained.

FINISHES

112. Color.—As has just been stated, the appearance of the stucco depends upon the manner in which it is finished with regard to color and texture. The matter of obtaining various colors has been considered under the head of the Composition of Stucco. When mortar stains are used, the mass of the stucco is colored uniformly. When, however, the color depends upon the color of the sand or broken stone which is mixed with the stucco, it is generally found necessary to clean away a film of cement which naturally covers these colored aggregates,

so that they may show in the surface of the wall. This is done by scrubbing the wall with brushes and clean water when the stucco is fresh, or by using dilute muriatic acid and brushes if the stucco is several days old. This treatment removes the film of cement and exposes the aggregates in their natural color and brilliancy and the color effect of the wall is determined by the color of these aggregates.

113. Texture.—The texture, or degree of roughness, of the surface of the stucco, has a great effect upon its appearance. A perfectly smooth and even surface can be obtained by using fine materials and working them to a perfectly uniform and smooth surface. It is found, however, that such a treatment is likely to prove flat and uninteresting in its effect. A rough surface is generally more interesting, due to the play of light and shade upon it caused by the projecting particles of mortar.

This texture is obtained by using coarse sand, grit, and pebbles in mixing the stucco, as well as by the method of applying the stucco. The wall surface may be finished smooth by using a steel trowel or it may be made rough by using a cork or wooden float or by placing a piece of carpet over the float. The surface may be roughened by stippling it before it has hardened and a rough but uniform effect obtained. The stucco is often thrown against the second coat and a rough surface produced. The stucco may be mixed with grit or small pebbles and thrown against the second coat and a very rough surface obtained.

Thus it will be seen that there are numerous devices used to obtain what are considered as desirable effects in the finishing coat.

114. Sand Finish.—A *sand-finished* or *sand-floated* surface is obtained by using coarse sand in the final coat. This coat is put on in the usual manner. When it has hardened slightly it is rubbed with a wooden float, using a circular motion which brings the sand to the surface of the stucco and gives a pleasing roughness or texture to the wall.

115. Rough Cast.—When the finishing coat is brought to an even surface, a mixture of cement and sand is thrown against the face of the wall by means of a small wooden paddle or a whisk broom so as to roughen it more or less uniformly.

116. Pebble Dash.—The finishing coat is brought to an even surface and pebbles varying in size from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch are thrown against the soft stucco surface so as to be distributed as evenly as possible. The pebbles should be wet and should be thrown against the surface with sufficient force to make them adhere, or they may be pressed into the stucco with a clean board.

117. Water Necessary.—The stucco should be kept moist at all times until it has been completed. It should be frequently sprayed or should be covered with wet burlap so that it will not dry out too soon.

EXAMPLES OF BUILDINGS OF HOLLOW TILE

118. Dwellings.—Hollow tile is used for dwellings of all kinds, such as bungalows, cottages, and mansions. Illustrations of a dwelling built of Denison load-bearing, or **H**-tile, blocks are given in Figs. 55 and 56. Fig. 55 shows the building ready for plastering and Fig. 56 shows the plaster or stucco coat in place. The stucco surface has been finished in rough cast and presents a coarse and vigorous texture. Figs. 57 and 58 are two dwellings built of **H** tile and ready to receive the stucco coating. These illustrations show quite clearly the methods used in building with hollow-tile blocks.

119. Apartment Houses.—Apartment houses are frequently built with walls of hollow tile, such tile being used for outside and inside walls up to the roof; and sometimes fire-proof floors are used.

Examples of apartment houses built of tile are shown in Figs. 59 to 64, inclusive. Fig. 59 shows an apartment building built of interlocking tile, or **T**-shaped tile. This illustration



Courtesy of the Denson Fire-Proofing Co., Mason City, Iowa

FIG. 55



Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa



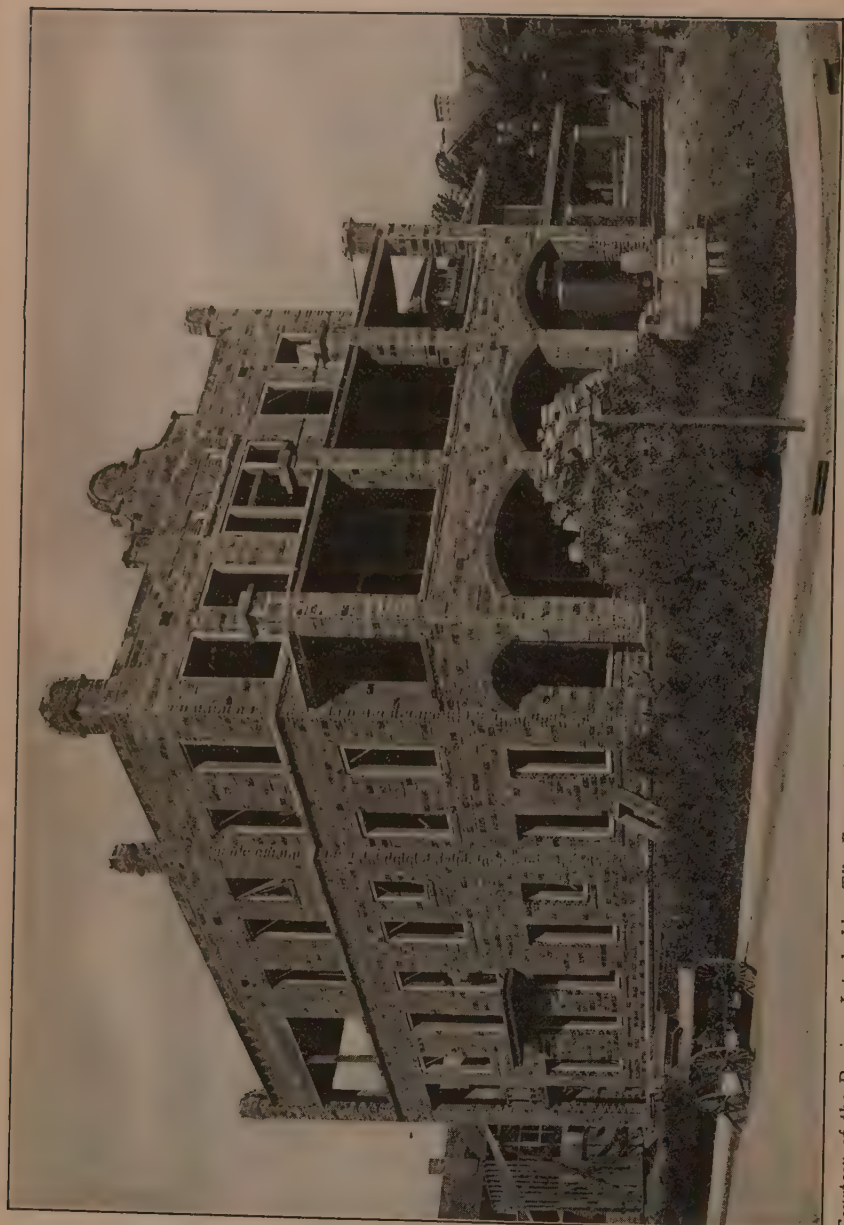
Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 57



Courtesy of the Demson Fire-Proofing Co., Mason City, Iowa

FIG. 58



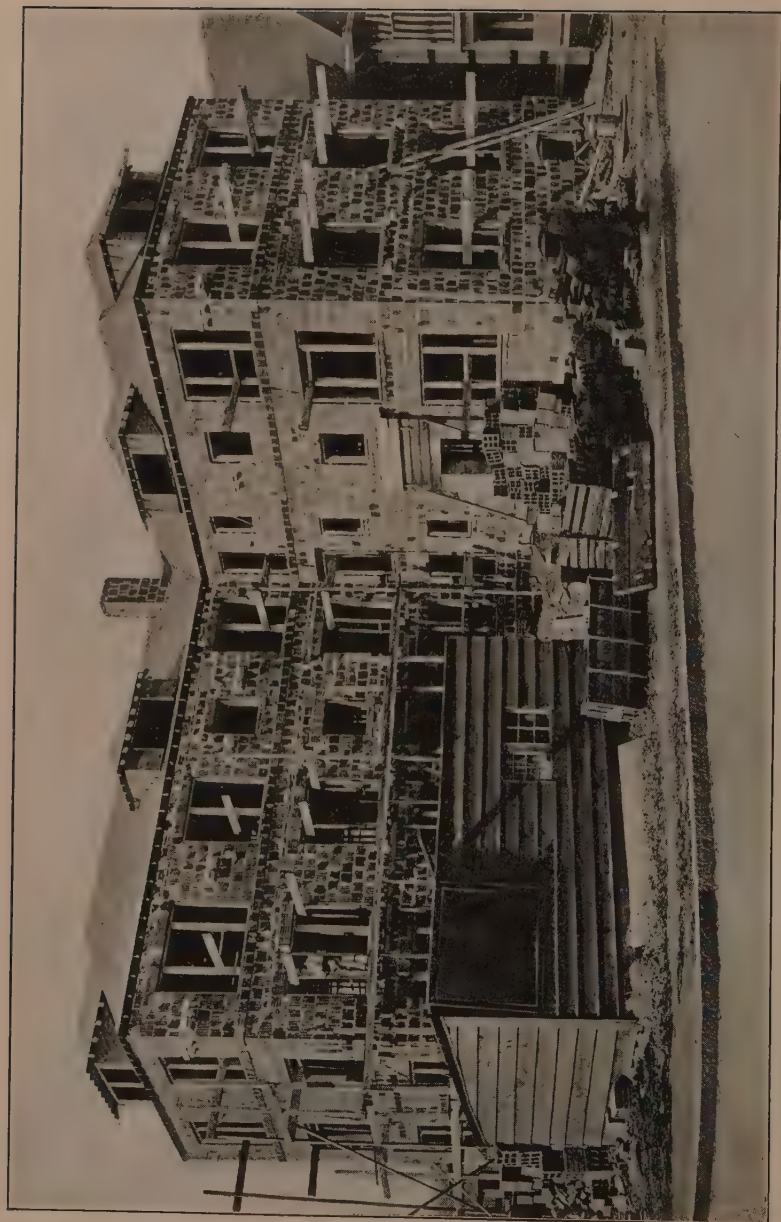
Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio

FIG. 59



Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio

FIG. 60



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 61

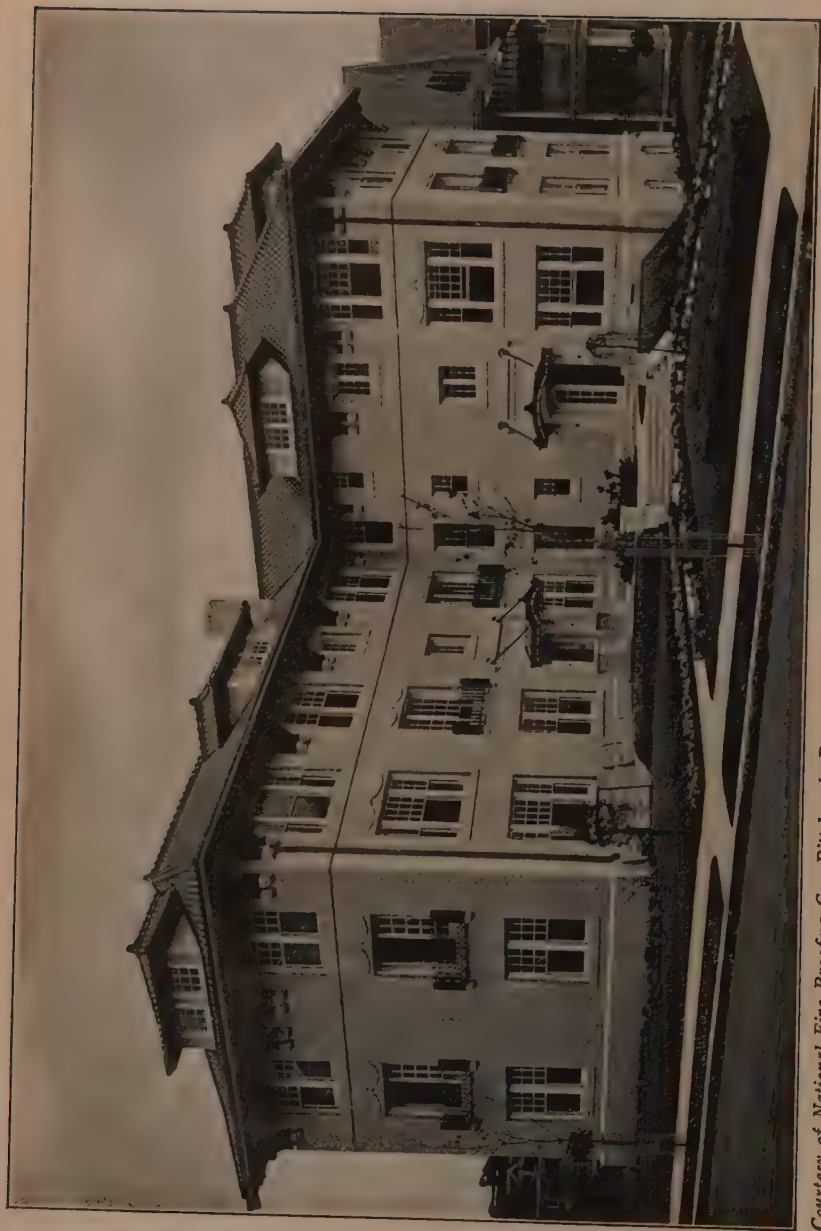
shows the characteristics of hollow-tile construction. The lintels and sills are made of tiles. In some cases corner blocks and jamb blocks have not been used. The cell openings show at the window jambs and corners but will be closed up with cement mortar and will present a satisfactory surface to receive the stucco. Segmental arches are shown on the front porch and are formed of face brick, as shown in the finished building, Fig. 60.

120. Fig. 61 shows an interesting example of hollow-tile construction built of Natco hollow tile. The sills and lintels are of tile as is also the sill course under the third-story windows. The chimney is also built of tile. Corbels of stone to receive the cornice brackets and the balconies are also shown in place. Fig. 62 shows this building finished with stucco rough cast, making a very attractive and interesting structure.

121. A very large apartment house is shown in Figs. 63 and 64. Fig. 63 shows the exterior walls built of Natco, or standard-shaped, tile. In this case the doorways, string-courses, and the trim of some of the windows are of stone and are built into the terra-cotta wall. The wall is shown with its stucco coating in Fig. 64. It will be noticed that the stucco in the first story has been treated to represent stone having rusticated joints. Quoins have been formed of stucco in the upper stories at the corners. The effect of this building is dignified and substantial.

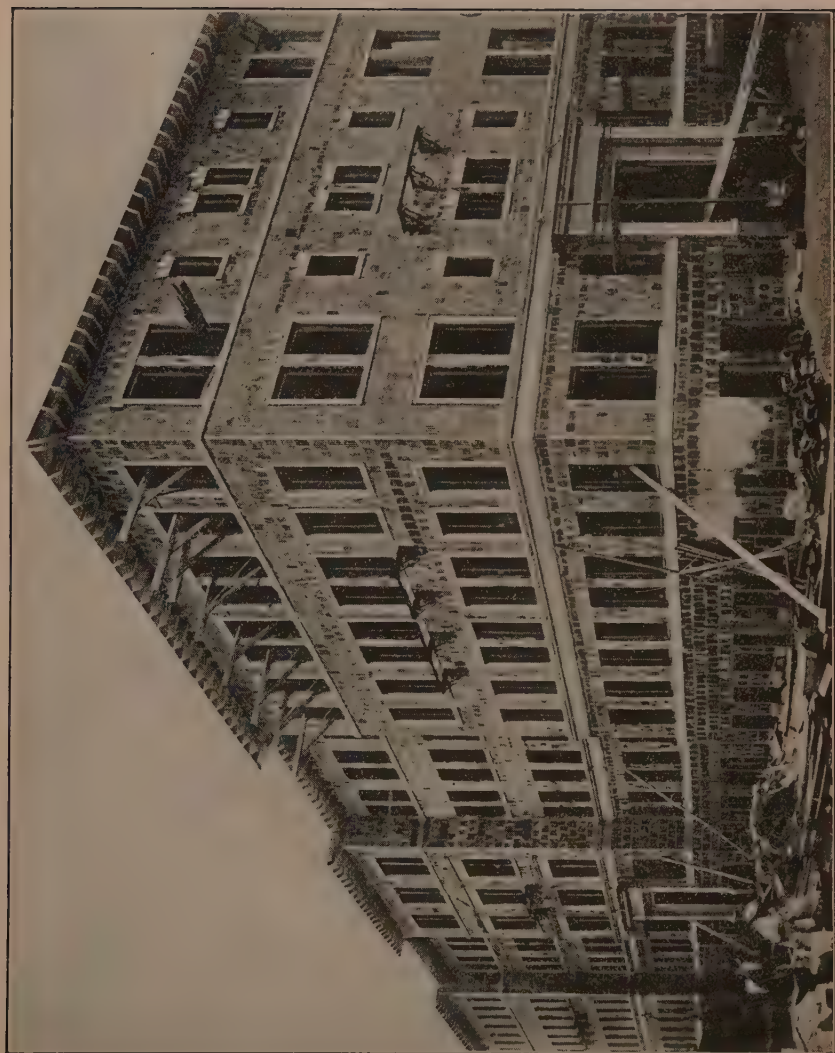
122. Factories and Warehouses.—In factories where very heavy loads do not occur, the same form of construction can be employed as for apartments and dwellings. Instead of interior tile partitions, however, steel columns and girders may be used. The outside walls can be made of hollow tile stuccoed, left with a smooth finish of the block showing, or veneered with brick.

Many of the latest types of factories and warehouses are built with a framework of reinforced concrete, consisting of posts, girders, and slab floors. After this framework is completed the spaces between the posts and girders on the outside walls are filled in with hollow tile as shown in Fig. 65. In this



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 62



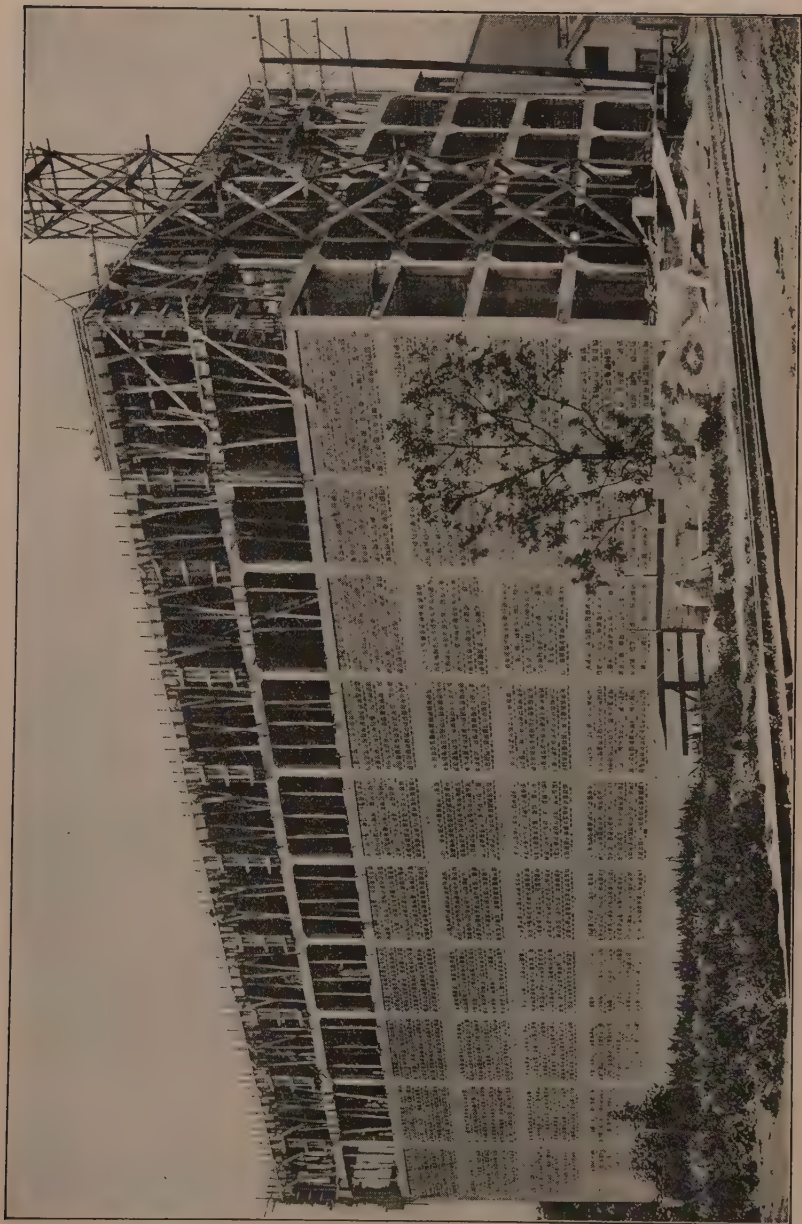
Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 63



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 64



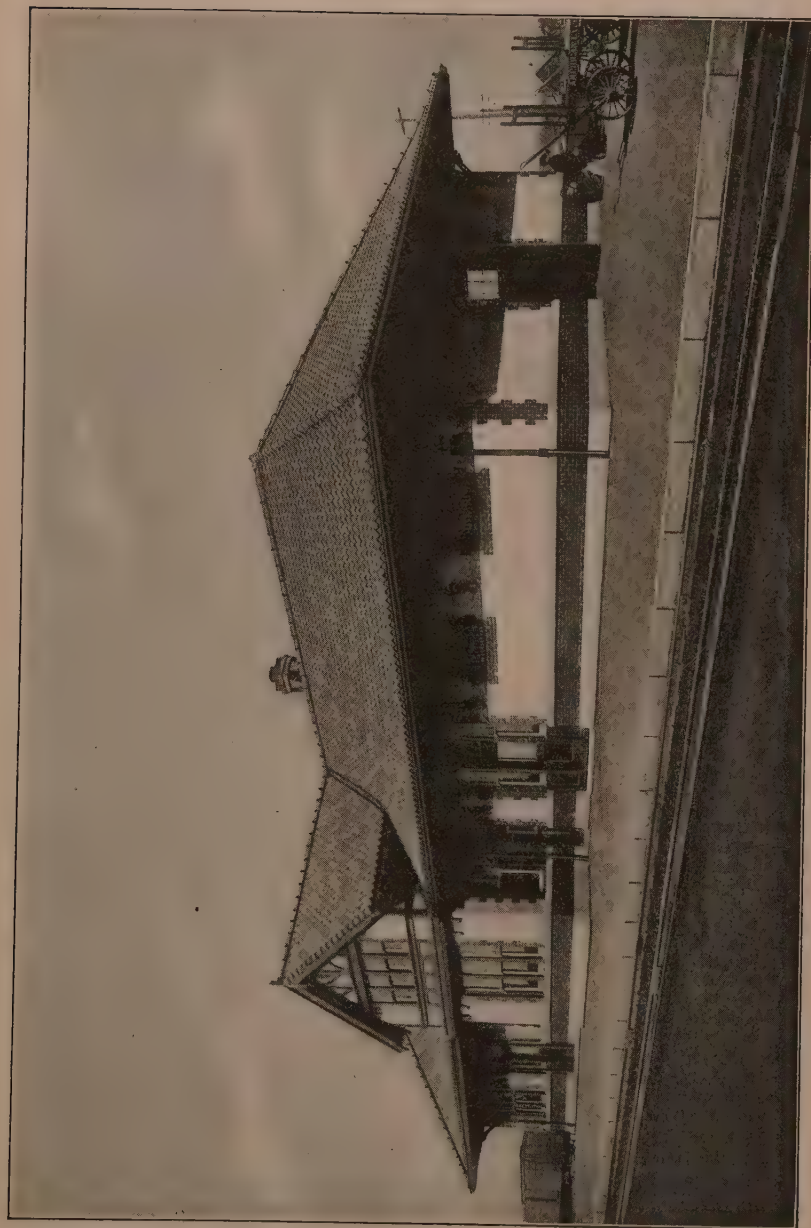
Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio

FIG. 65



Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 66



Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 67

case **T**-shaped, or Denison Interlocking, tile has been used. This filling-in is much lighter than brickwork and consequently does not require such heavy posts and girders to support it.

123. Office Buildings.—In tall office buildings, the framework is usually of steel, although in smaller buildings a reinforced framework is sometimes used. A considerable saving in weight and in the size and cost of the frame can be made by using hollow terra-cotta tile for filling in the walls between the columns and girders. These walls can, if desired, be veneered, or faced, with 4 inches of brickwork.

124. Railroad Stations.—An example of a railroad station built of Denison **H** tile is shown in Figs. 66 and 67. In Fig. 66 a stone base course and string-course are shown with a band of face brick between them. Above this is a hollow-tile wall. The windows are trimmed with face brick. The corners have a finish of face brick. Stone brackets and wooden brackets are built into the walls and the wall is ready for plastering. The finished building is shown in Fig. 67 and illustrates the possibilities of the use of hollow tile.

FIREPROOFING OF BUILDINGS

INTRODUCTION

GENERAL DISCUSSION

1. Fireproofing a building means building it of materials that will prevent, as far as possible, its destruction by fire. The materials used may form the supporting members of the structure or they may be the covering applied to protect these members from injury by fire. A fire that may start in the contents of such a building may develop great heat, but it should not seriously injure the building. The construction employed to obtain this result is generally known as *fireproof construction*.

A building is said to be of fireproof construction when its walls, partitions, floors, and roof are built of fireproof materials, when its steel or iron structural members are protected from the effects of fire by a covering of fireproof materials, and when the stairs, doors, door frames, window frames, sash, and casings are formed of incombustible materials that do not require to be covered by a fireproof covering.

2. Building Laws.—The building laws of most large cities contain detailed descriptions of the materials and forms of construction that may be used in fireproof construction within those cities. These materials and forms of construction are described in this Section. The architect or contractor should always familiarize himself with the specific requirements of the building laws of any city in which he wishes to do

business before beginning to design or construct a fireproof building.

3. Reasons for Making Buildings Fireproof.—In the United States, where the vast majority of buildings are built of wood, the annual loss of life and property by fire is enormous. Entire cities have been almost wiped out, with appalling losses of life and property. Such calamities could not happen if all buildings were of fireproof construction. Cities are therefore placing more and greater restrictions upon the erection of inflammable buildings within their limits, so as to prevent, as far as possible, the spread of fire from one building to other buildings in the neighborhood.

Notwithstanding these efforts on the part of municipal governments, the percentage of buildings that are of entirely fireproof construction is extremely small. Many buildings in cities have, however, partial protection from fire, such as masonry walls and fireproof roofs, which prevent the building from catching fire easily from the outside. There are, however, only too many cases where the interior construction of these buildings is of wood, which makes the interior of the building easily destructible by fire.

4. The principal reason why all buildings are not made of fireproof construction is that it costs much more to build them fireproof than otherwise. As long as this is the case, there will always be a great temptation to build non-fireproof or only partially fireproofed buildings. This is shown by the character of the buildings that are erected at the present time.

5. There are many good reasons why all buildings should be of fireproof construction. The principal reason is to prevent loss of life through fires. Cases are on record where many lives have been lost through the destruction, by fire, of factories, schools, theaters, hospitals, etc. Buildings such as these should always be made thoroughly fireproof, although frequently they are not.

The loss in property, by fire, is enormous and this is another excellent reason for making buildings fireproof. The destruction of a building by fire means an actual loss, even though the

value of the building and its contents are covered by insurance, as the material that entered into the construction of the building, as well as the contents of the building, has been destroyed. Even when a building is insured, the money received from the insurance company rarely covers the full actual loss, for during the time required to rebuild the building that has been burned, there is additional loss due to the interruption of the business that may have been carried on in the building. Much of this material and financial loss could be avoided if all buildings were of fireproof construction.

6. It should be remembered, however, that fires may occur in fireproof buildings when these buildings are filled with inflammable materials, and a serious fire in the contents of a building may interfere with the use of the building for a considerable time. The building itself, however, will not be destroyed and can again be put into a useful condition. A fireproof building will sometimes have a severe fire on one floor without affecting the floors above or beneath. Instead of spreading through the entire building and destroying it, the fire is confined within small limits by means of fireproof partitions, floors, ceilings, and the fireproofing that protects the steel structural parts of the building.

7. There are certain conditions under which it should be imperative that buildings be of fireproof construction. All buildings in the congested, or closely built, portions of cities should be of fireproof construction to prevent a fire in one building from spreading to those adjoining and causing a general conflagration. All school, office, factory, or other buildings that are over two or three stories in height, in which large numbers of persons are gathered or employed, should be of fireproof construction to prevent the possibility of a great loss of life through the destruction of the building or the inability of the occupants to leave the building safely while a fire is in progress.

8. Where capital is invested in a building with the view of securing a continuous and permanent revenue, the structure should always be of fireproof construction. The advantages of

this construction over other forms are that it is more permanent, the materials that enter into the building are more durable, and the cost for repairs is also small; also, the Fire Underwriters ask a lower rate, or premium, for insurance on buildings of this character. These items justify the greater initial expenditure that is required for this construction over less expensive forms.

9. Definitions of Terms.—Certain terms are used in connection with the discussion of fireproof buildings, and definitions of these terms are here given in order that their meaning may be understood as they occur in the following pages.

Conductors of heat are materials through which heat passes more or less freely. Steel and iron are materials of this character.

Non-conductors of heat are materials that do not permit heat to pass through freely; in such materials the part that is exposed to heat may have a high temperature, but this temperature decreases rapidly in the parts that are more distant or less exposed. All burned-clay products, concrete, plaster, and stone are non-conducting materials.

Combustible materials are those which may be entirely consumed by fire, such as wood.

Incombustible materials are those which can not be consumed by fire although they may be changed in form or even melt and their usefulness thus be destroyed. Steel and iron are materials of this character.

Fireproof materials are those which can not be consumed by fire and are non-conductors of heat. Burned-clay products and cement concrete are considered as fireproof materials and consequently are used to enclose and protect the incombustible materials that are essential to fireproof construction.

Fire retardant is a term used to describe any material or construction that tends to retard a fire and thus prevent it from reaching another part of the building or adjacent buildings.

Insulation is the placing of an incombustible or a fireproof material around a material that is affected by heat, to protect it from fire.

PRINCIPLES OF FIREPROOFING

10. General.—It is well known that steel and iron possess great strength and that they will not burn, but when used for structural purposes they are not fireproof materials. There is slight danger of steel beams and columns being melted by the heat of a burning building, but they may become hot enough to soften and fail when carrying a heavy load.

On the other hand, burned-clay products and concrete, while not possessing the strength of steel, are in the highest sense fireproof. The principle underlying fireproofing in general is, therefore, to encase or enclose all steel work that constitutes the supporting members of the structure, with a fireproof material, such as brick, terra cotta, or concrete, so that fire cannot reach this steel work or the heat from a fire affect it sufficiently to impair its strength.

Another principle is illustrated in the use of steel or iron in positions where they carry no loads. Steel or iron in the form of window and door frames, casings, sashes, and doors is in the highest sense fireproof. Under the heat of a fire such metals might expand, warp, or twist, but ordinarily they do not melt and they will retard the spread of the fire while adding nothing to the combustibles in the building.

11. Necessity for Steel and Iron.—As has been noted, steel and iron are not in themselves fireproof materials, yet they are absolutely necessary, in the construction of a fireproof building of any considerable height, to carry the loads. High fireproof buildings require a steel frame consisting of columns, girders, beams, trusses, etc., to furnish the necessary strength to support the loads that occur in the building and to support the protective enclosure of fireproof material that is fitted and attached to it.

Steel is also needed for reinforcing concrete which is used in fireproof construction. This steel is in the form of bars or of a heavy metal mesh which is buried in the concrete and is thus protected from fire.

FIREPROOF MATERIALS

12. Comparative Values of Fireproof Materials.

There are several substances that can be used to protect steel. Their value depends upon the ability of the material to endure great heat for a length of time, as well as to withstand sudden cooling, which occurs when a stream of water from a hose is turned upon it. The value of various substances as fireproof materials is determined from time to time by laboratory tests, and the results of these tests are published by the National Board of Fire Underwriters. The following general facts may be stated as the result of these tests.

13. Brick, terra cotta, and concrete are the best and most extensively used fireproof materials. Burned-clay fireproofing tile is made with different degrees of density. That which is the least dense is considered the most effective material from the standpoint of fire protection but it is not so strong as the denser tile.

14. Brick is as good a material as can be found from the fireproofing standpoint. It has greater strength than tile and is correspondingly heavier.

15. Concrete, which is a mixture of cement and sand with stone, gravel, or cinders, is very often used, also concrete that is reinforced with steel. If the latter form is used, the reinforcing steel should be well embedded in the concrete to insure a proper protection against the effects of the heat, otherwise the steel will expand and cause the concrete to break and crumble.

16. Stone does not rank high as a fireproofing material. While it may not fail in a structural sense when exposed to fire, its surface is apt to be cracked and chipped off and its appearance ruined. Hence, in the reconstruction of a building which has been subjected to fire, the stone usually requires to be replaced with new material.

17. Ornamental terra cotta, like structural terra cotta, is not affected by the heat of an ordinary fire and is a very good material for the surface treatment of buildings.

18. Plaster of Paris is a better heat retardant than tile, but it softens under the influence of heat and disintegrates when water is thrown on it, consequently it is not used as extensively as tile.

19. Sheet metal, as has been suggested, is not fireproof, but it is a most valuable material as a fire retardant, and is used extensively for this purpose.

FORMS OF FIREPROOF CONSTRUCTION

20. Methods and Materials.—Different forms of fireproof construction are obtained by the use of the various fireproof materials just mentioned in connection with structural and reinforcing steel.

The exterior walls may be formed of brick, stone, concrete, terra-cotta tile, or terra cotta backed with brick, or of a framework of steel or of reinforced concrete filled in with brick, terra cotta, or concrete. The steel in the steel frame must be covered with fireproof materials.

The interior bearing members may be walls of masonry or a framework of reinforced concrete or of steel covered with fireproof materials. The floors may have a framework of steel, protected by fireproof materials, and the floor construction may be of brick, terra cotta, or reinforced concrete or the entire framework and floor may be formed of reinforced concrete.

The partitions may be of brick, concrete, terra cotta, or else of plaster of Paris in the form of blocks or of mortar which is applied to metal lath and studding; the stairs may be of reinforced concrete or iron, and the door and window frames, doors, sash, and casings of sheet metal. The foregoing materials can be combined in various ways to construct a fireproof building.

21. The construction of walls of the various materials enumerated, reinforced-concrete structures, steel framework of buildings, and cast-iron and sheet-metal work are subjects that are covered in other Sections.

Structures formed of reinforced concrete are in themselves fireproof, but, being described elsewhere, will not be discussed in this Section, which will be limited to the description of fireproofing as it is related to the protection of the steel members that form the framework of a building, the construction of tile arches and concrete slabs which form the floors, the building of tile or metal lath and plaster partitions, and the use of some of the miscellaneous materials and forms of fire protection.

THE STEEL FRAME

22. Members of the Frame.—In order to understand the descriptions of the methods of fireproofing and of applying fireproof materials to steel work, it is necessary to have a knowledge of the names, locations, and purposes of the members that make up the steel frame, and also to be able to identify these members on a drawing. For large buildings a separate set of drawings is usually made which indicate the steel work only; such drawings are known as *framing plans*. These plans contain many indications that relate only to the steel work and which would be confusing were they shown on the regular plans. These framing plans are made in conjunction with the regular plans and require to be accurately drawn and the calculations carefully made to determine the size of the steel members that are required to carry the loads.

Three kinds of steel members that enter into nearly all steel-framed buildings are the *beams*, *girders*, and *columns*. The **beams** are the members that constitute the general floor framing and carry the floor arches or slabs. In Fig. 1, which shows a part of a floor framing plan, the beams are indicated at *a* and at *do.*, which is an abbreviation of the word ditto. Between the columns are members known as **girders**, shown at *b*, *c*, *e*, and *f*. The girders *b* are formed of two channels and are designed to carry part of the floor load and also part of the



Part of Floor Framing Plan

FIG. 1

weight from the outside wall of the building. At *c*, the girder consists of a single beam, which is larger than the regular floor-beam, as this girder is required to carry the floor load that comes from two of the floorbeams *a, a*, and also a similar load that comes from the floorbeams *d, d* of the adjoining panel. The girders *e* and *f* each consist of two members, these being required in order to carry a part of the floor loads and the masonry walls of the elevator shaft.

Where terra-cotta or brick arches are used between the beams, round steel bars, called *tie-rods*, are installed in the steel floor construction to prevent the beams spreading apart because of the thrust from these arches. Rods of this character are shown at *g, g*, Fig. 1, and are described later in this Section. The steel **columns** which support the girders and floorbeams are indicated by numbers 1, 2, 3 and 7, 8, 9.

In Fig. 2 are shown in perspective the floor and ceiling framing and the supporting columns as they will appear after the steel is erected and before it is enclosed in fireproofing material, the beams, girders, and columns being designated by the same letters and numbers as in Fig. 1.

23. The steel frames of tall buildings consist of a series of floor panels or bays similar to those shown in Fig. 1 between the columns #1, #2, #7, and #8, but vary in size to meet the peculiar requirements of the design. The columns extend from the footings below the basement floor to the roof and vary in size according to the loads they carry. In tall buildings the fireproofing of the interior steel beams and girders, the placing of the floor arches, and the enclosing of interior steel columns, is usually started as soon as two or three stories of the steel frame have been completed and follows in this ratio until the entire structure has been fireproofed. As this fireproofing progresses, the exterior walls are erected and the columns and girders in these walls are encased, so that frequently the fireproofing of the lower stories is completed and walls, ceilings, and columns are being plastered even before the steel work of the top story has been erected. This method insures rapid construction and a consequent saving of time.

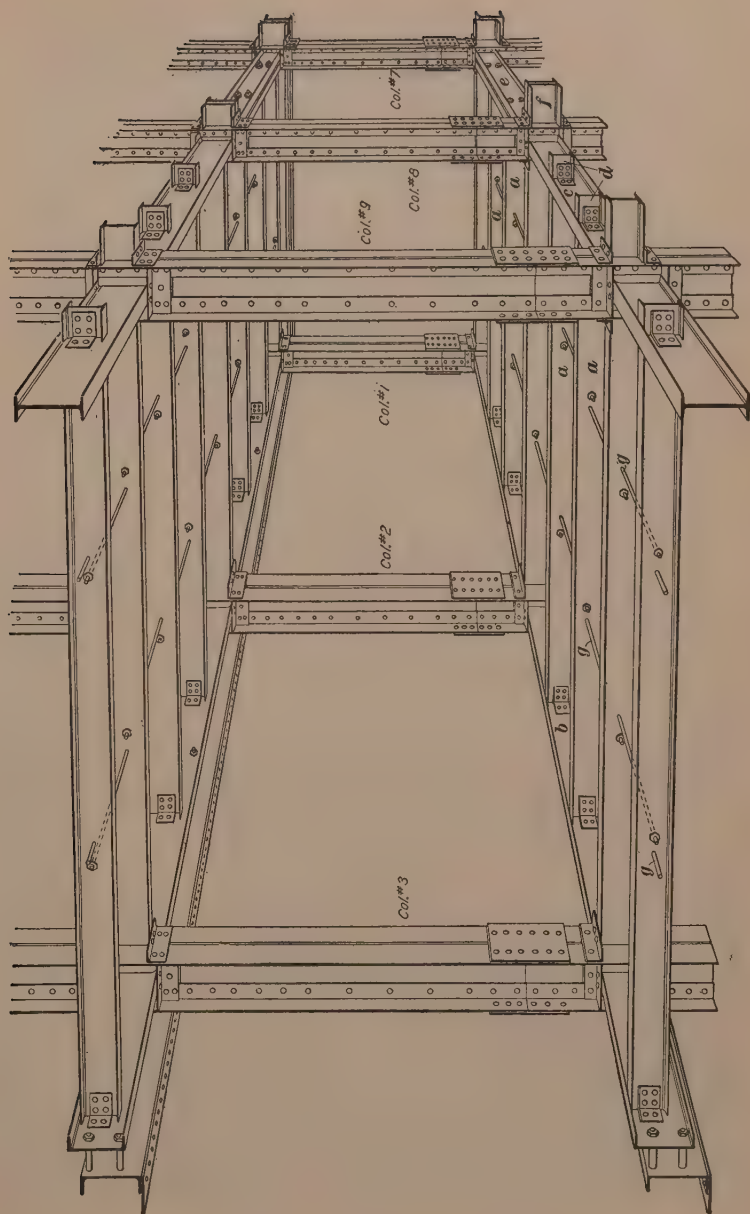


FIG. 2

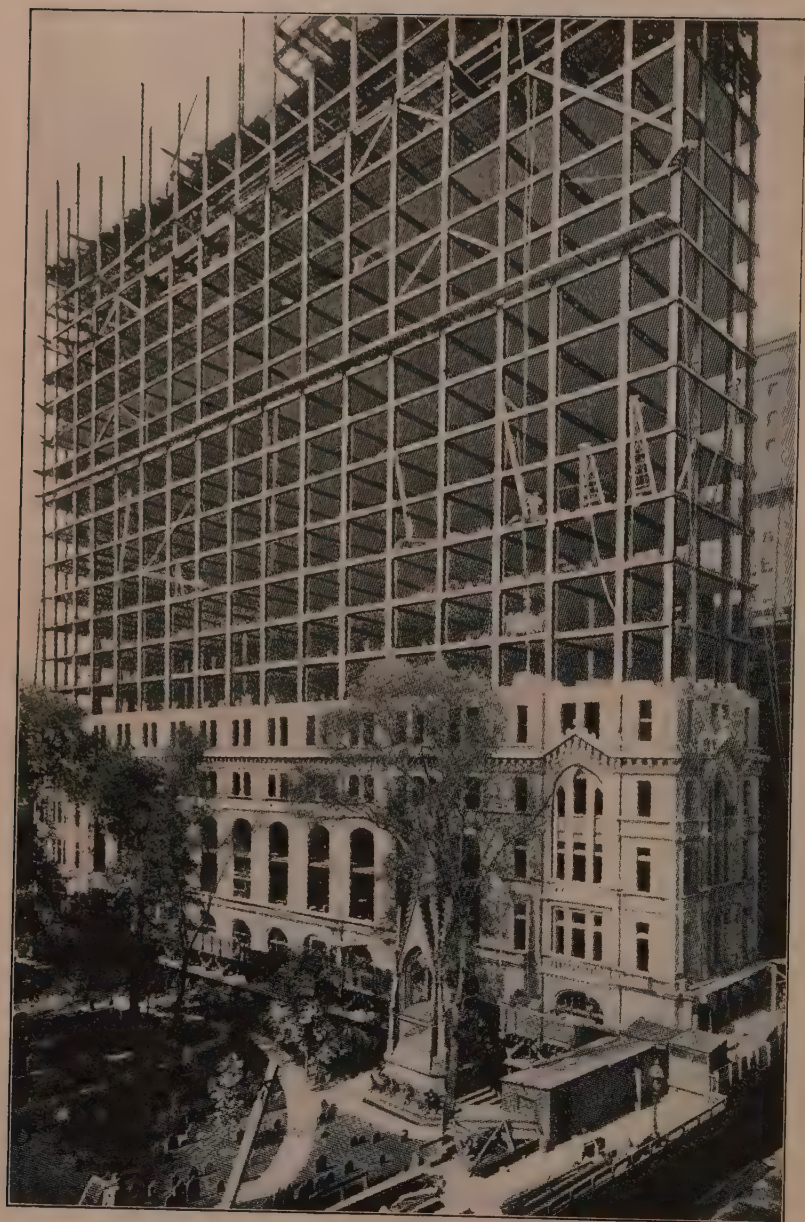


FIG. 3

In Fig. 3 is shown a steel-frame building which is under construction. The steel frame is shown to be incomplete at the top, the fireproofing of the floors has been installed to within a few stories of the finished part of the steel frame, and the exterior walls have been completed to the level of the sixth floor.

FIREPROOFING WITH TERRA COTTA

24. Kinds of Terra Cotta.—Terra-cotta fireproofing is made in different grades, *porous*, *semiporous* and *dense*, this difference being due in some cases to the process of manufacture. To make porous and semiporous terra cotta, some manufacturers mix a certain amount of sawdust with the clay and this is consumed in the process of burning the tile, thus forming small openings, or *air cells*, throughout the tile. The dense tile is made of clay or shale without any sawdust having been added to the mixture.

The grade of tile that is most generally used, however, is the *semiporous*, which is made of clay or shale. The porous nature is due to the character of the clay or shale that is used and also to the burning, the semiporous tile not being burned so hard as the dense grade.

The density of the tile is determined by the amount of water the tile will absorb. Some building codes stipulate that tiles shall not absorb over 10 or 12 per cent. of their weight of water.

25. Strength of Tile.—The strength of hollow tile that is of interest to the architect or builder is its strength in resisting compression, or crushing. This quality is important, as most terra cotta used for fireproofing is in compression. Hard-burned terra cotta will crush under a load of 4,000 to 5,000 pounds per square inch. As a safe working stress in terra-cotta floor arches, 500 pounds per square inch may be taken, as specified by the building code of New York City.

26. Construction.—When terra-cotta tile is used for fireproofing, the following methods of construction should be followed in the fireproofing of all beams, girders, and columns, and the forming of all floor arches and partitions:

Only cement mortar should be used for this construction, as lime mortar will not withstand the effects of the heat and water to which it might be subjected in case of a fire.

The edges of all tiles that are to adjoin each other should be well coated with the mortar and the pieces pushed together to insure that the mortar completely fills the joint. These joints should be carefully examined after the tiles have been set and any remaining openings should be closed with mortar so that the steel will not be exposed at these places.

It is well known that exposed edges and corners of materials are affected by fire more quickly than smooth flat surfaces, and for this reason all tiles should be placed in such a manner that smooth surfaces are obtained and projecting edges and corners avoided as far as possible.

FIREPROOFING OF GIRDERS AND BEAMS

27. Order of Procedure.—The usual order of procedure in fireproofing steel work is first to enclose the girders and such beams as project below the regular floor construction, then install the floor arches, and after the wood forms on which the arches are set have been removed, enclose

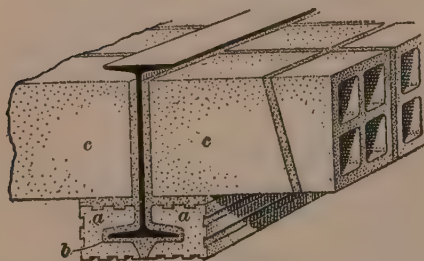


FIG. 4

the columns and build the partitions. The fireproofing of the steel will therefore be considered in that order, beginning with the girders.

28. Fireproofing a Single-Beam Girder.—One of the simplest forms of fire protection for a girder that is formed of a single large-sized I beam is shown in Fig. 4. The bottom flange of this girder is enclosed by two *clip tiles a*, which are held in place by the mortar *b* in which they are set. These clip

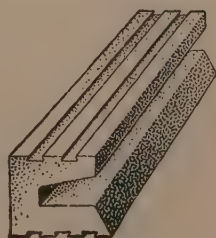


FIG. 5

tiles are solid in form and are shown in detail in Fig. 5. The floor tiles *c*, Fig. 4, rest directly upon the clip tiles and afford

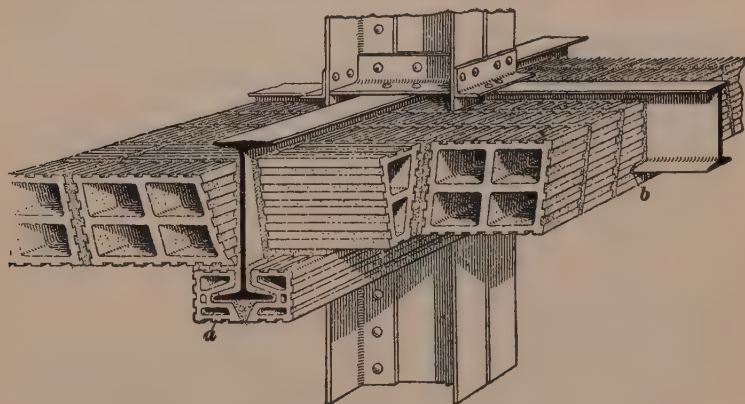


FIG. 6

protection to the web of the girder. The upper flange of the girder is protected by cinder concrete that is spread over the tops of the arches and floorbeams and beneath the finished floor, as will be shown further on.

A more elaborate form of clip tile is shown at *a* in Fig. 6 and in detail in Fig. 7. This tile has air cells in it which give it a greater fire-resisting value than that of the solid clip. The floor arches, as shown in Fig. 6, are supported upon the clip tile.

29. Fireproofing a Double I-Beam Girder.—A girder formed of two large I beams is illustrated in Fig. 8. The fireproofing consists of *clip tiles a*, which have already been described. On account of the width of the girder there is a space between the clip tiles that is filled in with a *soffit tile b*. The sides of the soffit tile are splayed, or beveled, and fit into the bevels of the clip tiles so as to form a good key. This prevents the soffit tile from dropping out. Resting upon the clip tiles, and supporting the floor tiles *d*, are *stretcher tiles c*, which are the size of a common brick. A detail of the soffit tile is shown in Fig. 9.

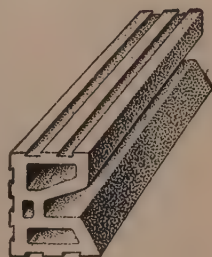


FIG. 7

30. Fireproofing a Box Girder.—Fig. 10 shows a box girder and a method of fireproofing it. A soffit tile *a* which is of the same width as the bottom flange of the girder is held in place against the under side of the girder by means of metal clips *b* which enter holes in the sides of the soffit tile and are bent over the flanges of the girder. This tile is set in mortar.

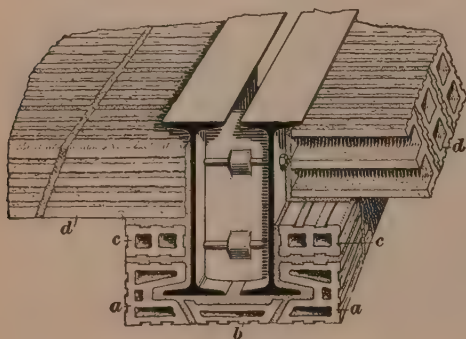


FIG. 8

Angle tiles *c* are then bedded in mortar on the top of the lower flanges and keep the metal clips in place as well as form a bearing for the tiles *d*, which are standard partition tiles. The partition tiles protect the sides of the girder and the top is protected by a layer of cinder concrete.

31. Protection of Floorbeams.—Floorbeams are fireproofed on the lower flange in the same manner as I-beam girders, that is, by the use of clip tiles. This method is employed when the floor arch is at the top of the beam and the beam projects below the under side of the arch. When, however, the lower flange of the beam is above the bottom of the arch, as shown at *b* in Fig. 6 and *e* in Fig. 10, the floor tiles are made with projections that extend beneath the I beam and cover the lower flange of the beam. When the flange of the I beam is wide, a soffit tile as shown in Fig. 11 at *d* is used. The *skews* *a* are set in mortar against the webs of the I beams. The sides of floorbeams are thus protected by the skew of the floor construction and the tops of the beams by a layer of cinder concrete, or cinder fill, shown at *h*.

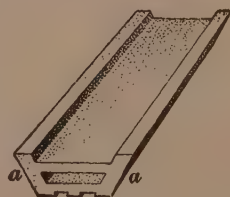


FIG. 9

FLOOR CONSTRUCTION OF TERRA COTTA

32. Types of Floor Construction.—Terra-cotta floors are formed of units or blocks, which are assembled on wooden forms and cemented together to form the various systems of floor construction shown in the illustrations which follow.

Terra-cotta floor construction may be of two forms, flat or curved. There are several varieties of the flat form, known as the *flat arch*, the *Johnson system*, the *combination system*, etc.

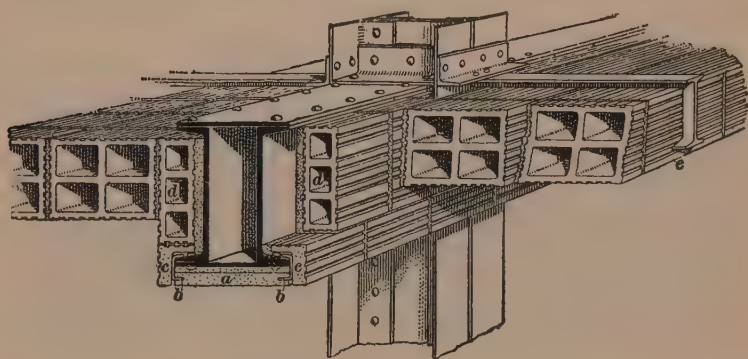


FIG. 10

The curved floors are represented by the *segmental arch* and the *Guastavino* system.

Arches or floor systems are also divided into two groups, known as long-span and short-span. A short-span arch or system is one which spans the space between the beams which divide a panel such as *hijk* in Fig. 1 into narrower sections as shown at *hilm*. A long-span arch or system is one that fills an entire panel such as *hijk* when the panel is not divided by intermediate beams such as *ml*. The span of a short-span arch may be from 3 feet to 10 feet but is usually from 4 to 6 feet. A long-span arch or system generally springs from girders and walls, while a short-span arch is placed between intermediate beams or between these beams and the girders and walls.

In some cases a long-span flat system may be supported on all four sides by being reinforced in both directions. More often, however, the reinforcement runs in one direction only.

FLAT ARCHES

33. The flat arch, as the name implies, is flat on the top and bottom. The blocks have sloping sides so that when they are assembled and the middle block, called the *key*, is put in place, an arch is formed which spans the distance between the bearings. There are three types of flat arches, which are named after the arrangement of the blocks in the arch: the *side-con-*

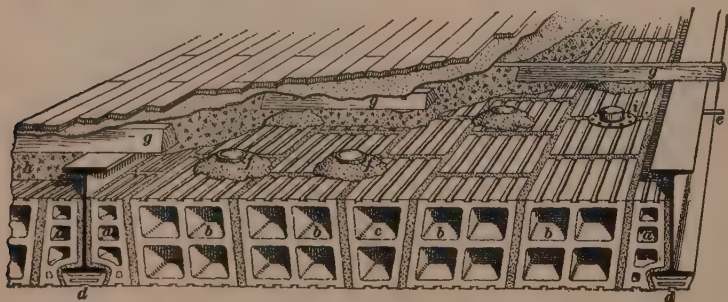


FIG. 11

struction arch, Fig. 11, the *end-construction arch*, Fig. 12, and the *combination side and end construction arch*, Fig. 13.

34. Side-Construction Flat Arches.—In Fig. 11 is shown in perspective a flat arch of the side-construction type. By side construction is meant that the tiles are laid with their cells running parallel with the steel beams. The tiles *a*, which rest against the I beam, are known as *skews* or *skewbacks*. The tiles *b*, which form the body of the arch, are known as *lengtheners*. In the center of the arch is the *key c*. Standard lengtheners are made about 12 inches in size, measured perpendicularly to the beams. Lengtheners are also made in smaller sizes, such as 3 inches, 6 inches, and 9 inches, so that variations in the span of the arch can be taken care of. Thus, one arch may have a span that will take full-size lengtheners, while an adjacent arch may be 6 or 9 inches wider and will

require a 6-inch or 9-inch lengthener to complete the arch. In this case the key will be at one side of the center of the arch.

The thickness or depth of flat arches of the side construction and the loads they will safely carry for different spans are given in Table I. The widest span permissible for each of the various depths of arches used in floor construction is indicated by cross lines in the columns. Loads that will be supported by longer spans are given below the lines, but such spans should be used only for ceiling construction, and a floor load should not be placed upon them.

The loads given in the table represent the gross loads, except

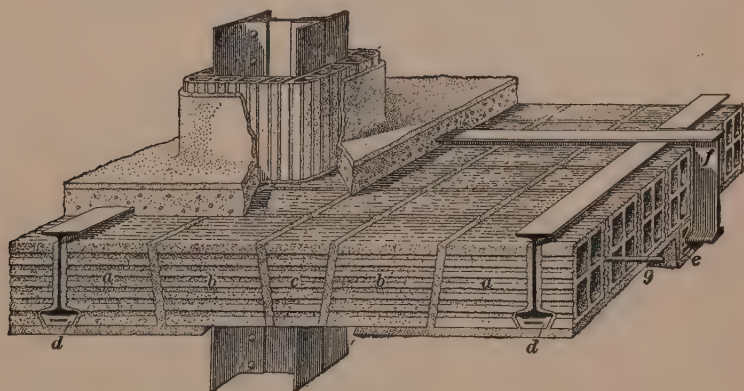


FIG. 12

that the weights of the arch tiles have been deducted. To obtain the safe live loads, the weights of the cinder filling, flooring, and plastering must be deducted. Cinder concrete weighs about 60 pounds per cubic foot; $\frac{7}{8}$ -inch maple flooring, $3\frac{1}{2}$ pounds per square foot; $2'' \times 4''$ sleepers with cinder filling between, $8\frac{1}{2}$ pounds per square foot; and plaster applied to the under side of the arch tile, 5 pounds per square foot. The tie-rod shown at *e*, Fig. 11, wooden grounds at *f*, wooden sleepers *g*, concrete filling *h*, and the floor finish shown in this illustration will be described further on

35. End-Construction Flat Arches.—In end-construction flat arches, as shown in Fig. 12, the cells in the tiles run crosswise from beam to beam instead of parallel with the

beams, as in the side construction. The chief advantage of this form of arch is that it possesses about fifty per cent. more

TABLE I

SAFE LOADS FOR SIDE-CONSTRUCTION FLAT ARCHES

(Materials, semiporous. Factor of safety, 7. National Fire Proofing Co.)

Depth of Arches	6 Inches	7 Inches	8 Inches	9 Inches	10 Inches	12 Inches	15 Inches
Weight of Arch per Square Foot	26	29	32	36	38	44	54
Span Feet and Inches	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot
3-0	439	515					
3-3	370	434	500				
3-6	314	371	427	509			
3-9	270	320	368	439	514		
4-0	234	276	319	382	448		
4-3	204	243	280	335	393	543	
4-6	<u>178</u>	213	246	296	347	480	
4-9	158	188	218	262	308	427	549
5-0	140	167	193	233	275	382	491
5-3	124	149	173	209	246	343	442
5-6		<u>133</u>	155	188	221	309	399
5-9		118	139	169	200	279	362
6-0		107	125	153	181	253	329
6-3			<u>113</u>	138	164	231	300
6-6			102	125	149	210	274
6-9			92	114	136	192	251
7-0				<u>104</u>	124	176	231
7-6				86	<u>104</u>	148	196
8-0					87	126	167
8-6						<u>107</u>	<u>144</u>
9-0						91	124
9-6						78	107

strength than an arch of the side construction having the same weight and depth. Owing to this fact almost all of the arches

now built are of the end construction or of a combination of side and end construction.

In the end construction, shown in Fig. 12, the skewbacks *a* are similar in shape to the adjoining lengthener blocks *b*, with the exception that the ends of the skewbacks are square and the lower parts are cut out to fit around the steel beam. A key block *c* is required for the arch, and soffit tiles *d* of the hollow form are placed under the beams. In this illustration are also shown the clip tile *e*, which has been applied to the steel girder *f*, and a tie-rod at *g*.

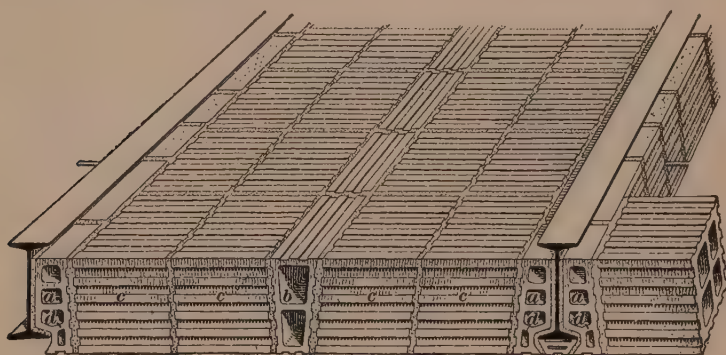


FIG. 13

36. Combination Side and End Construction Flat Arches.—One serious objection to end skewbacks is the lack of protection they afford the web of an I beam, particularly if the lip of the tile or the soffit tile which protects the lower flange of the beam is broken away, as the heat and flames can then reach the side of the beam, thereby weakening it more rapidly. To overcome this defect and still retain the strength and other good features of end construction, combination arches, as shown in Fig. 13, are formed of heavy side-construction skews *a*, side-construction keys *b*, and end-construction lengtheners *c*. End keys are stronger than side keys and are sometimes used when keys of greater length than 6 inches are required. By using side skews, the side of the beam is protected by the mortar in which they are bedded and by the webs of the skews, so that the entire skew would have to fail and

TABLE II

SAFE LOADS FOR END-CONSTRUCTION AND COMBINATION-
CONSTRUCTION FLAT ARCHES*(Materials, semiporous. Factor of safety, 7. National Fire Proofing Co.)*

Depth of Arches	6 Inches	7 Inches	8 Inches	9 Inches	10 Inches	12 Inches	15 Inches
Weight of Arch per Square Foot	26	29	32	35	38	42	50
Span Feet and Inches	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot	Pounds per Square Foot
3-0	482						
3-3	410	525					
3-6	354	453	563				
3-9	308	394	491	597			
4-0	271	347	431	525	627		
4-3	240	307	382	465	555		
4-6	214	274	341	414	495		
4-9	192	246	306	372	444	608	
5-0	<u>173</u>	222	276	336	401	548	
5-3	157	201	250	304	364	497	
5-6	143	183	228	277	331	453	
5-9	131	<u>168</u>	208	254	303	415	614
6-0		154	191	233	278	381	563
6-3		142	176	215	256	351	519
6-6		131	<u>163</u>	198	237	324	480
6-9			151	184	220	301	445
7-0			140	<u>171</u>	204	280	414
7-6			122	149	<u>178</u>	243	360
8-0				131	156	214	317
8-6				116	138	190	281
9-0					123	<u>169</u>	250
9-6						152	225
10-0						137	<u>203</u>
10-6						124	184
11-0							167
11-6							153

break away before flame could reach the side of the I beam. The points of greatest pressure in a flat arch are near the top of the keys and at the bottom of the skewbacks. To withstand this stress, skewbacks require a reinforcing web as shown at *d*. The absence of a reinforcing web at this place is very apt to cause the arch to fail.

37. The weight, depth, and safe load of end-construction and combination-construction flat arches can be found in Table II. The widest span permissible for each of the various depths of arches used in floor construction is indicated by the cross lines in the columns. Loads that will be supported by longer spans are given below these lines, but such spans should be used only for ceiling construction, and a floor load should not be placed on them.

The weights of the arches have not been deducted from the safe loads in this table, therefore the weight of the tile, cinder filling, flooring, and plaster must be deducted to obtain the safe live load for any arch and span.

38. A rule that applies to all three forms of flat arches just described is that the deeper the tile, within reasonable limits, the stronger the arch they will make, and for the same depth of beam a lighter and cheaper floor is obtained by filling the space with tile of the full depth of the beams rather than with other filling such as cinders or concrete. For instance, a 12-inch hollow-tile arch will weigh less and cost less per square foot than a 10-inch-tile arch with 2 inches of concrete filling on top of it.

39. Building-Ordinance Requirements.—While the loads in Tables I and II are safe as given, the thickness of the arch that may be used in certain large cities is regulated by the building laws. In determining the thickness of arch that is to be used in any building, the strength of the arch is not the only element to be considered, but, in addition, the building regulations should be consulted.

The ordinances of the city of Chicago require that "flat arch hollow tile or flat arch porous clay tile floor arches shall have a height of at least $1\frac{1}{2}$ inches for each foot of span."

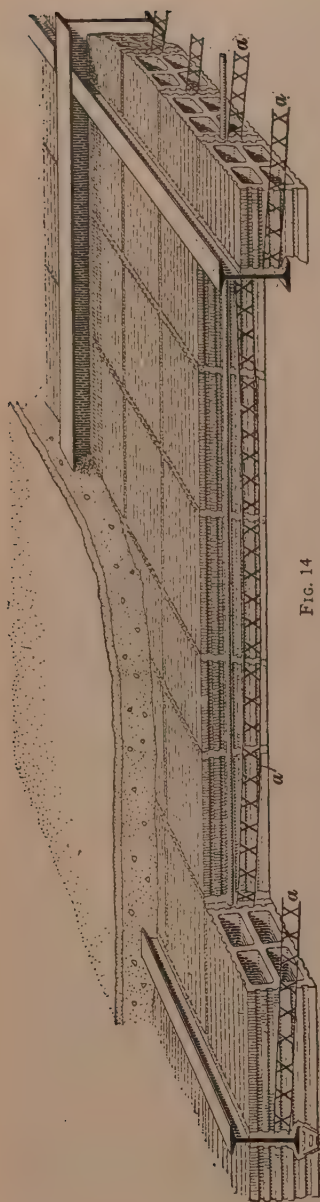


FIG. 14

The ordinances of San Francisco require that "flat arches shall have spans not exceeding 10 feet and the depth of the tile shall not be less than $1\frac{3}{4}$ inches for each foot of span."

The New York City laws require that "when terra cotta filling is in the form of flat arches, the depth of the blocks, unless reinforced with steel, shall not be less than $1\frac{1}{2}$ inches for each foot of span between steel beams, exclusive of the portion of the block projecting below the under side of the beams."

Thus, a flat arch of terra cotta for a span of 4 feet and projecting 1 inch below the lower flange of the I beams, would have to be made $1\frac{1}{2} \times 4 = 6$ inches deep in Chicago, $1\frac{3}{4} \times 4 = 7$ inches deep in San Francisco, and $1\frac{1}{2} \times 4 + 1 = 7$ inches in New York City. If the arch projected 2 inches below the bottom of the I beam, it would have to be made 6 inches in Chicago and 7 inches in San Francisco, but would have to be 8 inches deep in New York City.

Tiles having depths of 11 inches, 13 inches, 14 inches, and above 16 inches are not manufactured, hence when this rule gives the sizes 11, 13, or 14 inches the next larger size must be used. For instance, if in designing terra-cotta flat arches according to rule

we find that the arch must be 13 inches in depth, it will be necessary to use 15-inch tile, as 13-inch and 14-inch tile are not manufactured.

40. Reinforced Flat Tile Arch.—In Fig. 14 is shown a **reinforced hollow-tile arch** that can be made much shallower than other flat arches, is light and comparatively inexpensive, yet strong. For a span of 6 feet other arches require a depth of 9 or more inches, while with this construction the depth needs to be only 6 inches. Arches of this depth and for this span are allowed to be used by many of the building departments for live loads of 150 pounds per square foot.

Arches of this form are adapted to wide spans with shallow beams or wherever a light, strong, sound-proof and fireproof floor is desired. This arch is of the end-construction form and the reinforcement consists of wire trusses placed in the joints between the tiles as shown at *a*. This reinforcement has a bearing on the lower flange of the steel beams and is bedded in cement mortar and is thus protected from the heat in case of fire. This wire-truss reinforcement is shipped to the building in reels and there cut into proper lengths as required.

41. Centering and Construction of Arches.—In Fig. 15 is shown the same part of the steel framework of a building that was previously illustrated in Fig. 2. In Fig. 15, however, the tile arches have been completed in the lower floor, as shown at *a*, and the section through one of the arches at *b* shows that it is of a combination side and end construction arch. The location of the tie-rods is shown at *c*. The lower flange of one of the wall channels *d* and the interior steel girder *e* have been covered with clip tile of the hollow form.

The ceiling of this story, or the floor above the completed one, has the wooden forms in place ready to receive the tile arches. These forms consist of timbers which span over several steel beams as shown at *f, f*, and corresponding timbers *g, g*, placed below these same beams and suspended from the upper members by means of rods *h*. On the timbers *g* are placed the planks *i* that form the floor on which the tiles are laid when constructing the arches.

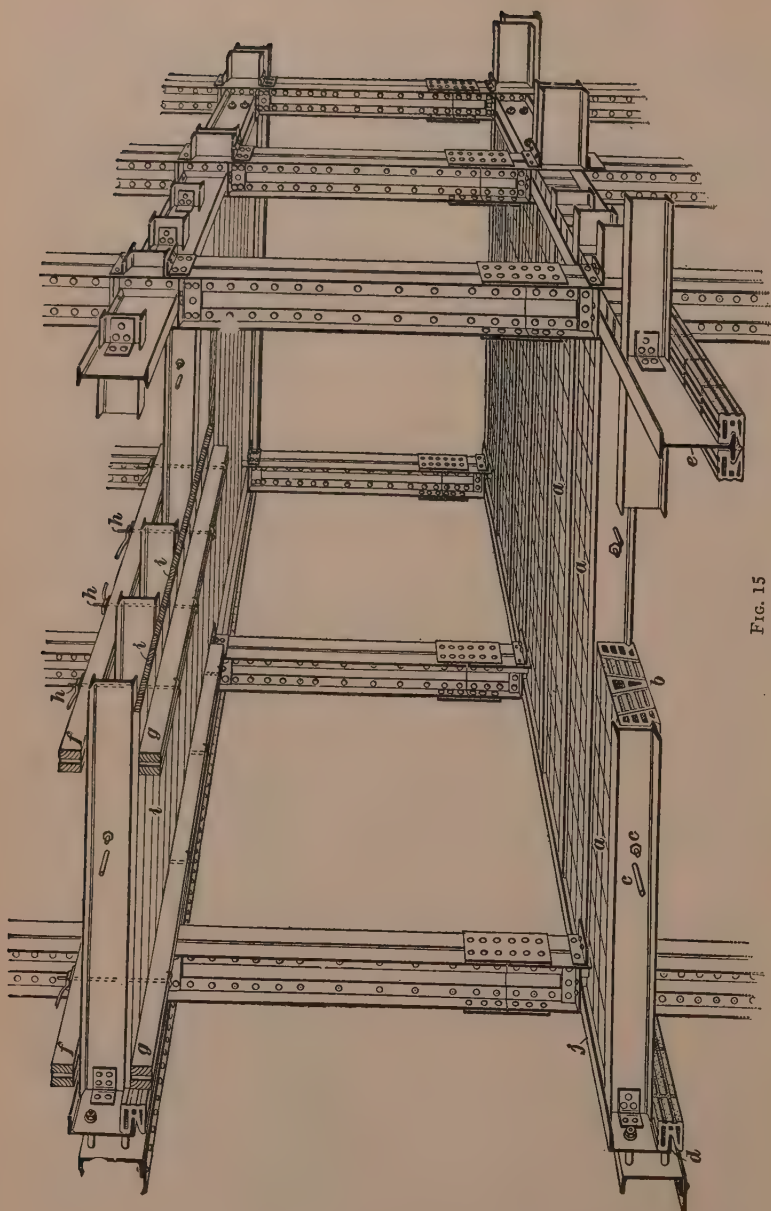


FIG. 15

The members *f* and *g* are formed of two 2"×6" timbers that are separated by means of small blocks but otherwise secured together, and a space is thus formed between the timbers through which the rods may pass. The lower ends of these rods are bent to form hooks that will support the timbers *g*, and the upper ends are provided with threads, washers, and winged nuts, which permit of adjustments being made and of the forms being located at just the required height and level.

The arch is formed by placing the skewbacks first, then the lengtheners, and lastly the keys. After the mortar has become hard the winged nuts are unscrewed and the wooden floor and lower timbers of the forms are allowed to drop to the floor below, from which they are removed and taken to an upper story, there to be installed and used again in the same manner as described, the process being repeated until all floors have been completed. In this figure it will be noted that the channel *j* which forms part of the outside wall girder has been fireproofed before the forms for the floor construction are placed. The other channel of this wall will be enclosed in the masonry of the wall when it is built.

42. Tie-Rods.—In all arches, flat or segmental, a thrust is exerted against the steel beams, and tie-rods must be provided in the structural steel work to prevent the beams from spreading. Tie-rods are shown at *g* in Figs. 1 and 2.

In flat-arch construction the greatest thrust is at the top of the key and at the bottom of the skew of the arch. The tie-rods are placed preferably at a point about 3 or 4 inches above the bottom of the beams and are spaced according to the depth of the beam or the span of the arch.

The tie-rods are spaced not more than 8 feet apart; usually they are spaced at distances of eight times the depth of the beams. For flat tile arches with spans of 6 feet or less, $\frac{3}{4}$ -inch tie-rods spaced about 5 feet apart are used; for 7-foot spans, $\frac{7}{8}$ -inch rods spaced 5 feet apart, and for 9-foot spans, $\frac{7}{8}$ -inch rods spaced 4 feet apart.

The thrust of segmental arches is considerable, and the line of the thrust is about the center of the skew. This would make

the most effective location for the tie-rods, near the bottom of the beams. They may be placed there and painted, but this exposes them to the heat from a fire and might cause the failure of the arches if the fire were a severe one. It is the general practice, therefore, to locate them where the material of the arch protects them from the heat of a fire, though this location may not be the most effective for resisting the thrust of the arch.

In constructing the arches, it is desirable to place the tiles so that a joint will occur at the tie-rods, and thus avoid the cutting of the tile to fit around the rod. Where this is not possible the cutting of the tile should be carefully done and the blocks repaired in such a manner that the arch will not be weakened by this operation.

43. Filling.—In a fireproof building, under no circumstances should the space between the top of the flat arch and the floor above, or the space above the haunches of segmental arches, be left open for the free circulation of fire. This space should be filled with cement concrete. Cinder concrete is commonly used for this filling, although for long-span arches gravel or fine-stone concrete is frequently used, as this will add to the strength of the arch.

44. Grounds and Sleepers.—In the filling are set sleepers made of wooden strips to which a wooden floor may be nailed. The sleepers are attached to the steel beams by means of clips, or they are attached to the floor construction by the use of spot grounds, as shown in Fig. 11 at *f*. These spot grounds are circular pieces of wood firmly secured to a metal collar, as shown at *i*. This collar is cemented to the top of the terra-cotta arches by strong cement mortar, the top of the ground being placed at the proper level.

SEGMENTAL ARCHES OF HOLLOW TILE

45. Characteristics of Segmental Arches.—The segmental arch is the strongest form of arch known. For this reason it is particularly adapted for floors of warehouses,

lofts, factories, or wherever great strength is required and a flat under surface or ceiling is not necessary. A standard form of construction of the segmental arch is shown in Fig. 16 (a). The skewbacks *a* are formed so that the upper part conforms to the shape and size of the arch block, while the lower part has a lip similar to a clip tile, to hold the soffit tile shown at *b*. This form of construction thoroughly fireproofs the steel work but requires a beam finish in the ceiling, as well as curved surfaces between the beams.

Fig. 16 (b) shows skews that are used in connection with segmental arches when a flat ceiling is desired. These skews

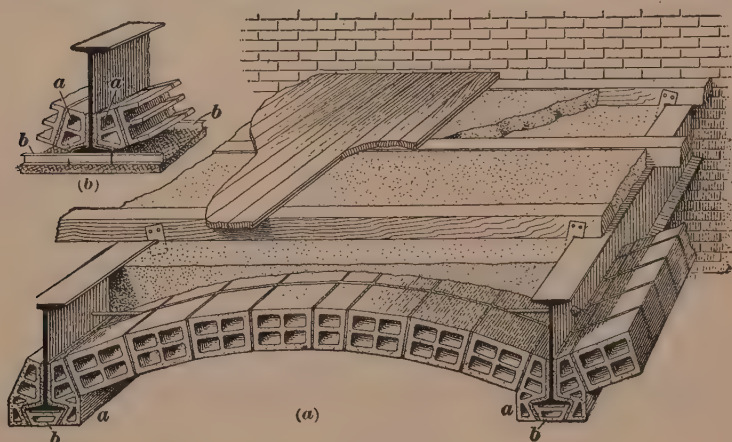


FIG. 16

have no lower lips to protect the lower flange of the I beam, but a suspended ceiling supported on small channels *b* is installed which in a measure protects the flange of the beam. This protection is, however, not so effective as that given by the tile enclosure.

Six-inch or 8-inch hollow tiles are generally used for segmental arches. The 6-inch arch of side construction is the standard used for all ordinary purposes. The rise of the side-construction arch can be increased by increasing the thickness of the upper parts of the mortar joints.

The *rise* of the soffit of an arch above the springing line should be from one-tenth to one-eighth the span of the arch.

TABLE III
SAFE LOADS FOR SEGMENTAL ARCHES OF HOLLOW TILE, IN POUNDS PER SQUARE FOOT

Span Feet	Rise Inches	4-Inch Arch Pounds	6-Inch Arch Pounds	8-Inch Arch Pounds	10-Inch Arch Pounds	Span Feet	Rise Inches	4-Inch Arch Pounds	6-Inch Arch Pounds	8-Inch Arch Pounds	10-Inch Arch Pounds
4	$\frac{3}{8}$ in.	702	902	1,078	1,178	7	$\frac{3}{8}$ in.	394	508	606	662
	1	920	1,184	1,414	1,545		1	520	669	799	873
	$\frac{1}{2}$	1,155	1,485	1,774	1,939		$\frac{1}{2}$	648	834	996	1,089
	$\frac{3}{4}$	1,353	1,740	2,079	2,272		$\frac{3}{4}$	762	981	1,171	1,280
	2	1,545	1,986	2,373	2,593		2	876	1,127	1,346	1,471
$4\frac{1}{2}$	$\frac{3}{8}$ in.	1,736	2,233	2,667	2,915	8	$\frac{3}{8}$ in.	983	1,264	1,510	1,650
	1	616	792	946	1,034		1	341	439	525	573
	$\frac{1}{2}$	812	1,044	1,247	1,363		$\frac{1}{2}$	457	588	703	768
	$\frac{3}{4}$	1,020	1,313	1,568	1,713		$\frac{3}{4}$	562	724	864	944
	2	1,196	1,539	1,838	2,009		2	668	859	1,026	1,122
5	$\frac{3}{8}$ in.	1,381	1,775	2,121	2,318	9	$\frac{3}{8}$ in.	767	987	1,179	1,288
	1	1,536	1,975	2,359	2,578		1	854	1,099	1,312	1,434
	$\frac{1}{2}$	551	709	847	926		$\frac{1}{2}$	300	386	461	504
	$\frac{3}{4}$	744	957	1,143	1,249		$\frac{3}{4}$	403	518	619	677
	2	911	1,172	1,400	1,530		2	501	645	770	842
6	$\frac{3}{8}$ in.	1,072	1,379	1,647	1,800	10	$\frac{3}{8}$ in.	590	758	906	990
	1	1,238	1,592	1,902	2,078		1	677	871	1,041	1,137
	$\frac{1}{2}$	1,379	1,773	2,118	2,315		$\frac{1}{2}$	759	977	1,167	1,275
	$\frac{3}{4}$	455	585	699	764		$\frac{3}{4}$	267	344	411	449
	2	612	788	941	1,028		2	359	462	552	603
	$\frac{3}{8}$ in.	753	969	1,157	1,265		$\frac{3}{8}$ in.	447	576	688	751
	1	898	1,154	1,379	1,507		1	531	683	816	892
	$\frac{1}{2}$	1,022	1,315	1,570	1,716		$\frac{1}{2}$	610	784	937	1,024
	$\frac{3}{4}$	1,148	1,476	1,763	1,927		$\frac{3}{4}$	683	879	1,050	1,147
	2						2				

NOTE.—The weight of the arch tile has been deducted in table so that only the dead load of concrete fill, plastering, etc. must be deducted to obtain net live load.

TABLE IV
SAFE LOADS FOR SEGMENTAL ARCHES OF HOLLOW TILE, IN POUNDS PER SQUARE FOOT

Span Feet	Rise Inches	4-Inch Arch Pounds	6-Inch Arch Pounds	8-Inch Arch Pounds	10-Inch Arch Pounds	Span Feet	Rise Inches	4-Inch Arch Pounds	6-Inch Arch Pounds	8-Inch Arch Pounds	10-Inch Arch Pounds
11	1	327	421	503	550	16	1	218	281	336	367
	1 $\frac{1}{2}$	404	519	621	678		1 $\frac{1}{2}$	274	353	421	460
	1 $\frac{3}{4}$	479	617	737	805		1 $\frac{3}{4}$	325	419	500	546
	2	551	709	847	925		2	374	481	575	628
	2	617	794	948	1,036		2	420	540	645	705
12	1	297	383	458	500	18	1	192	248	296	324
	1 $\frac{1}{2}$	370	477	569	622		1 $\frac{1}{2}$	240	310	370	404
	1 $\frac{3}{4}$	439	566	676	738		1 $\frac{3}{4}$	287	370	442	482
	2	505	649	776	848		2	330	425	507	554
	2	565	727	869	949		2	371	477	570	623
13	1	272	351	419	458	20	1	172	221	265	289
	1 $\frac{1}{2}$	339	437	522	570		1 $\frac{1}{2}$	215	277	331	361
	1 $\frac{3}{4}$	403	519	620	677		1 $\frac{3}{4}$	257	330	395	431
	2	463	596	712	778		2	296	381	455	497
	2	521	670	801	875		2	332	427	510	558
14	1	253	326	390	426	22	1	154	199	237	259
	1 $\frac{1}{2}$	315	406	485	530		1 $\frac{1}{2}$	194	250	298	326
	1 $\frac{3}{4}$	374	482	575	629		1 $\frac{3}{4}$	232	299	357	399
	2	430	553	661	722		2	268	344	412	450
	2	481	619	740	808		2	301	377	462	505
15	1	234	302	361	394	24	1	140	181	216	236
	1 $\frac{1}{2}$	292	377	450	491		1 $\frac{1}{2}$	177	227	272	297
	1 $\frac{3}{4}$	347	447	534	583		1 $\frac{3}{4}$	211	272	325	355
	2	401	515	616	673		2	244	314	375	410
	2	449	577	690	754		2	274	353	421	460

NOTE.—The weight of the arch tile has been deducted in table so that only the dead load of concrete fill, plastering, etc. must be deducted to obtain net live load.

If the proportions are one-tenth, a 6-foot arch would require a rise of 7.2 inches, while with a ratio of one-eighth the rise would be 9 inches.

46. Long-Span Segmental Arch.—The *long-span fireproof floor construction* is a logical result of the effort to cut down the amount of structural steel required in a building without reducing the strength of the structure. The less the dead weight of the floor, the less will be the size, weight, and expense of columns, girders, and the general structure. Segmental floor arches have been successfully used for all lengths of spans up to and including 25 feet. These arches are exceptionally strong, but they exert a great thrust upon the supporting beams between which the arches are sprung. To withstand this thrust, the outer bays of the floors sometimes have reinforced flat arches, and no tie-rods are used; in other installations the thrust is taken care of by steel tie-rods from beam to beam. Notwithstanding the strength of the long-span segmental arches, they are not used extensively, the more practical flat-arch combination system being preferred on account of giving a flat ceiling.

47. Safe Loads for Short-Span Segmental Arches. In Table III will be found the safe loads, in pounds per square foot, for segmental arches of various depths, built of semi-porous tile with $\frac{5}{8}$ -inch webs and shells, of side construction and with various rises as indicated in the second column. A factor of safety of 7 is allowed. The spans covered by this table are from 4 feet to 10 feet, inclusive, which will include all ordinary short-span arches.

48. Safe Loads for Long-Span Segmental Arches. In Table IV are given the safe loads for segmental arches having spans from 11 to 24 feet, which will include all ordinary long spans.

GUASTAVINO ARCHES

49. Guastavino arches are formed of several layers of flat tile, so laid and embedded in cement mortar that they will form a solid shell-like construction when completed.

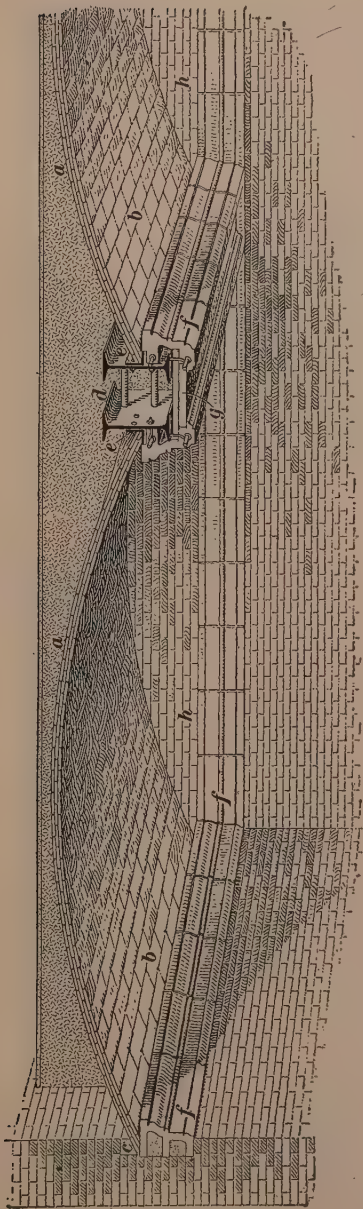


FIG. 17

The tiles are made of the same materials as regular dense terra-cotta fireproofing, with the exception that those intended for exposed ceilings are made in the various colors and textures that are possible in architectural terra cotta. These tiles are about 1 inch thick, 6 inches wide, and from 12 inches to 24 inches long, and the tiles of one layer break joints with those of the other layers, thus securing a bond.

50. In Fig. 17 are shown parts of two Guastavino segmental arches which are formed of three layers of tiles as above described. A section through the arches is shown at *a, a*, and the finished under side of the arches at *b*. One side of the arch springs from the wall of the building, a recess *c* being formed in the wall to provide a suitable bearing. Midway between these walls is the steel girder *d*, which is formed of two I beams. To these beams are attached angles *e*, from which the inner edges of the arches are sprung. A terra-cotta belt-course *f* is carried around

the walls to provide a suitable finish at the spring line of the arches, and members of the same form are used to enclose the steel girder, a soffit member *g* being provided to make a finished terra-cotta beam of this enclosure. Regular face brick are used for the walls of the building above the terra-cotta course at the ends of the arches, as shown at *h*.

51. Wooden forms are required in constructing these arches, and on these forms the first layer of tile is placed to form the design desired. If a ceiling construction is being formed, as is shown in Fig. 17, the tiles are spaced to provide uniform-size joints, and wooden wedges are placed in these joints to preserve this spacing. A heavy coating of cement mortar is applied to the upper surface of this first layer of tile and the joints between the tiles are thoroughly filled. While this mortar is still soft, the second layer of tile is laid and pressed into it, and this process is continued until the required number of thicknesses or layers has been laid.

When the arch has been completed and the mortar become set, the forms are removed, the mortar that has overlapped the tiles on the face *b* of the arch is cut away, and the joints are finished as desired.

These arches are used for floor, ceiling, and roof construction. They may be built in the form of single arches, vaults, or domes. The number of layers of tile required will depend upon the dimensions of the arch and the load it is required to carry. Floors built on this principle have been tested and found to carry very heavy loads. When such work is contemplated, however, the architect should consult with the representative of a company that erects these arches, as it is usual for such a company to determine what strength of construction is required to take the loads and thrusts from the arch, vault, or dome that is to be constructed.

LONG-SPAN FLOOR SYSTEMS

52. There are several floor systems in which terra-cotta tile is used, that are frequently referred to as arches. These systems are in no sense arches, as they are not built in accor-

dance with the principles of the arch. They are, however, popularly called floor arches and will be referred to as arches in the following articles.

53. Herculean Flat Arch.—A long-span arch known as the Herculean is shown in Fig. 18. The arch is usually built

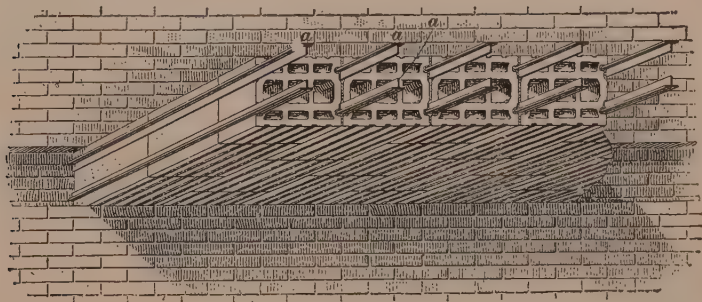


FIG. 18

from wall to wall or from beam to beam and consists of a special form of tile which has grooves in the sides into which are placed **T** irons that give strength to the construction. These **T** irons are bedded in the grooves at each longitudinal joint, and should be thoroughly embedded in the mortar so that they

TABLE V

DIMENSIONS AND SAFE LOADS FOR HERCULEAN ARCHES

Depth of Arch Inches	Weight Pounds per Square Foot	Safe Length of Span Feet	Safe Load Pounds per Square Foot
6	30	12	100
8	33	15	200
10	42	16	400
12	53	20	500

will be protected from rust. **I** beams are not needed for this construction, and the arch presents flat surfaces both for the floor and the ceiling. The depth of blocks used for this type of arch depends upon the length of span. The depth of arch,

weight of arch including steel reinforcement, length of span in feet, and safe load per square foot can be found in Table V.

54. Johnson-System Floor.—In Fig. 19 is shown the Johnson-system floor. This system consists of the regular form of tile as shown at *a*, and a reinforcement of steel in the form of wires *b* interwoven with larger wires *c* placed about 4 inches apart. These larger wires run straight from bearing to bearing. These floors can span a space of as much as 25 feet; they rest on bearings for support and exert no thrust as does an actual arch.

In constructing floors by this system, the steel-wire mesh is bedded in concrete, hollow-tile blocks are laid thereon, and the

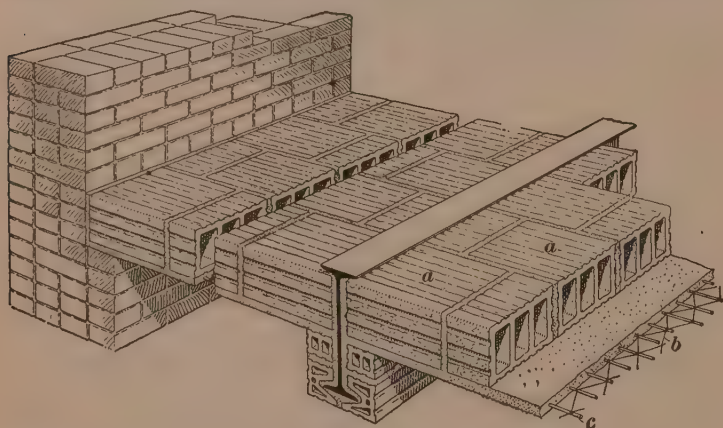


FIG. 19

wide joints between courses are filled with concrete. The arch shown in this illustration has no concrete on top of the tiles. In practice, floors are laid in this manner, but in some cases they have one, two, or more inches of concrete on top of the tiles. Adding 1 inch of concrete top finish adds about 50 per cent. to the strength of the arch, and adding 2 inches of concrete to the top of the tiles increases the strength of the arch over 100 per cent.

55. Safe Loads for Johnson-System Floors.—The safe loads for the Johnson-system floors, as given by the manufacturers, can be found in Tables VI and VII. These values

TABLE VI
SAFE LOADS FOR JOHNSON-SYSTEM FLOORS WITHOUT A CONCRETE TOP FINISH, IN POUNDS PER SQUARE FOOT

Area Reinforcing = Steel	12-Inch Tile .64 Square Inch	10-Inch Tile .57 Square Inch	9-Inch Tile .51 Square Inch	8-Inch Tile .47 Square Inch	7-Inch Tile .42 Square Inch	6-Inch Tile .38 Square Inch	5-Inch Tile .31 Square Inch	4-Inch Tile .25 Square Inch	3-Inch Tile .22 Square Inch
Span Feet	Weight of Floor per Square Foot, 55 Pounds	Weight of Floor per Square Foot, 52 Pounds	Weight of Floor per Square Foot, 48 Pounds	Weight of Floor per Square Foot, 45 Pounds	Weight of Floor per Square Foot, 42 Pounds	Weight of Floor per Square Foot, 37 Pounds	Weight of Floor per Square Foot, 35 Pounds	Weight of Floor per Square Foot, 29 Pounds	Weight of Floor per Square Foot, 27 Pounds
5	...	...	...	...	...	...	446	353	213
6	...	...	...	...	579	470	311	227	147
7	...	...	488	553	425	341	223	165	113
8	...	...	...	422	324	263	171	125	79
9	...	507	383	333	254	206	132	113	61
10	558	407	308	264	202	163	105	76	48
11	458	337	253	219	165	133	86	62	
12	386	282	210	179	137	111	71	51	
13	326	234	178	152	116	93	59		
14	278	202	152	129	98	78	49		
15	241	175	130	111	84	68	42		
16	210	151	113	97	73	58			
17	189	133	99	75	63	51			
18	164	117	87	72	56	45			
19	146	103	77	66	49				
20	129	92	68	58	43				
21	117	83	61	51					
22	104	75	54	46					
23	95	67	49						
24	86	61	44						
25	77	55							

TABLE VII

SAFE LOADS FOR JOHNSON-SYSTEM FLOORS HAVING 2 INCHES OF CONCRETE TOP FINISH, IN POUNDS PER SQUARE FOOT

Area Reinforcing = Steel	12-Inch Tile 1.0 Square Inch	10-Inch Tile .95 Square Inch	9-Inch Tile .90 Square Inch	8-Inch Tile .86 Square Inch	7-Inch Tile .82 Square Inch	6-Inch Tile .73 Square Inch	5-Inch Tile .68 Square Inch	4-Inch Tile .68 Square Inch	3-Inch Tile .6 Square Inch per Foot Width
Span Feet	Weight of Floor per Square Foot, 79 Pounds	Weight of Floor per Square Foot, 77 Pounds	Weight of Floor per Square Foot, 72 Pounds	Weight of Floor per Square Foot, 69 Pounds	Weight of Floor per Square Foot, 66 Pounds	Weight of Floor per Square Foot, 62 Pounds	Weight of Floor per Square Foot, 59 Pounds	Weight of Floor per Square Foot, 54 Pounds	Weight of Floor per Square Foot, 51 Pounds
7	...	...	...	...	...	...	...	...	569
8	...	...	...	...	...	...	...	567	437
9	...	...	...	...	...	...	568	442	342
10	...	...	...	...	...	530	435	354	272
11	...	...	...	...	514	435	355	292	224
12	...	...	572	508	429	365	298	242	187
13	...	568	487	428	364	310	255	204	157
14	...	491	417	368	311	265	215	174	
15	...	421	362	318	269	230	185	151	
16	470	368	317	278	236	200	162		
17	415	326	277	243	207	175	142		
18	368	287	245	215	182	155	125		
19	325	251	219	190	161	137			
20	292	228	195	170	146	121			
21	265	206	175	153	129				
22	238	185	160	139	116				
23	218	168	143	125					
24	196	153	130						
25	178	138							

are given for general information only, as each particular floor should be designed for the purpose for which it will be used. A factor of safety of 4 is allowed. It will be noted that the arch in Table VI has no concrete top finish, while the arch in Table VII has a 2-inch concrete top finish.

56. Combination Hollow-Tile and Reinforced-Concrete Floor Construction.—A long-span system of floor construction consisting of reinforced-concrete beams and hollow tile is illustrated in Figs. 20 and 21. The strength of this floor depends upon the reinforced-concrete beams shown at *a*, Fig. 20, and *f* in Fig. 21. The steel rods furnish the neces-

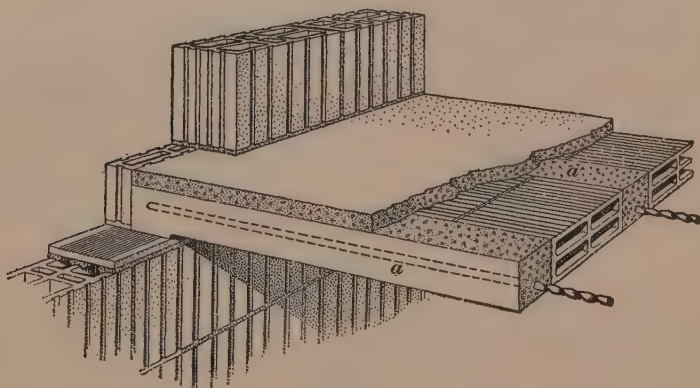


FIG. 20

sary tensile strength for these beams, and the tile makes a light floor construction. The strength of this type of floor can be varied to suit circumstances. Fig. 20 is the simplest form and is designed for use in residences and other buildings where the floor loads are light. Fig. 21 is a form that is designed to support heavy loads, and the reinforced beams contain two rods. One of these rods is bent up and carried over the tops of the I beams as shown. Still stronger beams can be made by making the beams deeper and adding more steel. The design of concrete beams will be taken up in the Section entitled *Design of Beams*.

57. The combination floor is built upon forms, consisting of posts *a*, Fig. 21, stringers *b*, and planks *c*. The planks are placed under the beams in such positions that the edges of the tiles *d* will rest on two adjacent planks. Rods are placed in the spaces between the tiles, and concrete is poured to fill these spaces. The rods must be kept off the plank so as to be entirely covered with concrete. After the pouring of the concrete has begun a man goes along with a rod having a hook on the end of it and slightly raises the reinforcing rods so that the concrete may flow beneath them. A layer of concrete 2 inches or so in

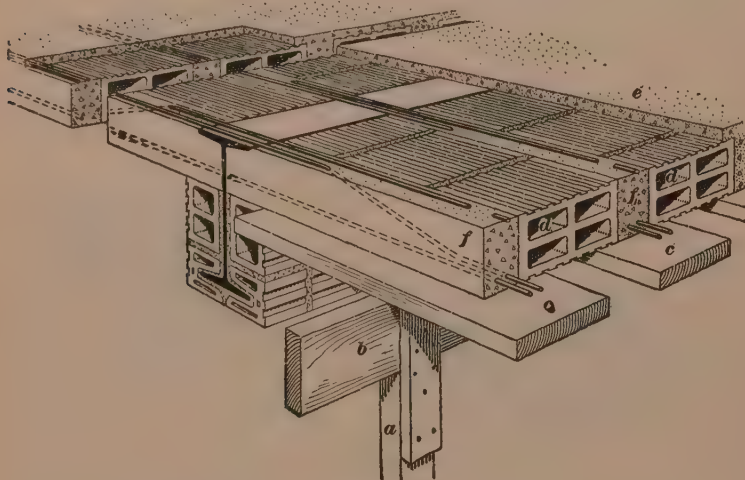


FIG. 21

thickness is poured over the top of the blocks and the beams, as shown at *e*. This layer of concrete adds greatly to the strength of the floor construction.

58. Combination floor systems are comparatively inexpensive on account of the economy of centering, and are desirable on account of having great strength combined with lightness. They are convenient for the plasterer on account of having three-fourths of their surfaces scored with dovetail grooves which form keys for the plaster, and the flat ceilings they present make them desirable for all kinds of buildings.

TABLE VIII

SAFE LOADS FOR COMBINATION REINFORCED CONCRETE AND HOLLOW TILE FLOORS, 2-INCH CONCRETE TOP FINISH, IN POUNDS PER SQUARE FOOT

Span Feet	15-Inch Tile 1½-Inch Diameter Rod	12-Inch Tile 1½-Inch Diameter Rod	10-Inch Tile 1½-Inch Diameter Rod	9-Inch Tile 1½-Inch Diameter Rod	8-Inch Tile 1½-Inch Diameter Rod	7-Inch Tile 1½-Inch Diameter Rod	6-Inch Tile 1-Inch Diameter Rod	5-Inch Tile 1-Inch Diameter Rod	4-Inch Tile ¾-Inch Diameter Rod
	Weight of Floor per Square Foot, 106 Pounds	Weight of Floor per Square Foot, 92 Pounds	Weight of Floor per Square Foot, 82 Pounds	Weight of Floor per Square Foot, 76 Pounds	Weight of Floor per Square Foot, 72 Pounds	Weight of Floor per Square Foot, 67 Pounds	Weight of Floor per Square Foot, 62 Pounds	Weight of Floor per Square Foot, 54 Pounds	Weight of Floor per Square Foot, 50 Pounds
5	7,024	5,226	4,488	3,289	2,988	2,623	1,801	1,361	934
6	4,849	3,598	3,088	2,264	2,053	1,798	1,228	930	634
7	3,534	2,608	2,248	1,640	1,488	1,305	890	669	452
8	2,680	1,983	1,702	1,239	1,023	983	657	500	334
9	2,094	1,548	1,328	974	872	765	513	383	254
10	1,678	1,236	1,060	766	693	605	404	300	196
11	1,368	1,004	862	619	560	489	323	238	153
12	1,134	830	711	508	459	399	262	192	120
13	949	696	593	421	381	331	214	155	95
14	804	586	500	353	318	276	176	126	59
15	686	499	425	298	268	231	145	103	46
16	591	427	364	253	227	195	120	84	35
17	511	368	313	215	192	166	99	78	26
18	444	312	270	184	164	140	83	54	18
19	388	276	234	157	140	119	67	44	12
20	340	240	203	134	119	101	54	35	6
21	298	209	177	115	101	86	44	26	
22	263	183	154	98	86	72	34	19	
23	231	159	134	83	73	61	27	7	
24	204	139	126	70	61	50	19		
25	179	121	101	59	50	41	13		

The safe load, in pounds per square foot, for this type of long-span flat arch, having 2 inches of concrete top finish, can be found in Table VIII. The factor of safety used is 4.

59. Two-Way Systems.—There are long-span systems formed of reinforced beams and hollow tile in which the beams run in two directions at right angles to each other and the blocks are held between the beams. These systems can be made very strong so as to span a distance of 25 or 30 feet. This economizes in the number of intermediate steel beams or reinforced-concrete beams that will be required. Special forms of tiles are used to close up the open ends of the regular tile so that the concrete will not enter them.

FIREPROOFING STEEL AND IRON COLUMNS WITH TERRA COTTA

60. General.—As the stability of a building in case of fire depends upon the protection of the columns from failure, the greatest care should be exercised to see that they are adequately fireproofed with good non-heat-conducting materials,

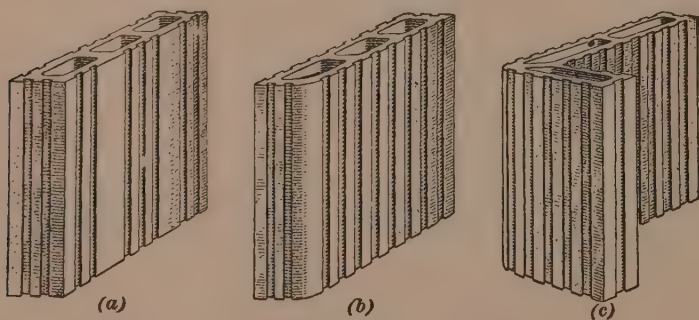


FIG. 22

and also protected from corrosion. Hollow tile is the best burned-clay product to use for enclosing the columns, and if the outside face of the tile is plastered, an additional protection is obtained. The tile should be at least 3 inches thick and be laid with the vertical joints broken to secure a good bond. The

space inside of the tile enclosure of the column should be filled with concrete, as this material not only protects the column

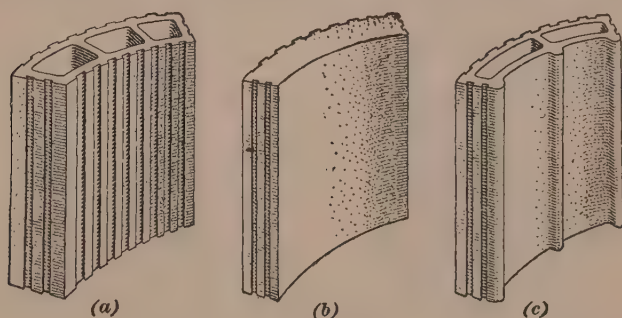


FIG. 23

from corrosion but it adds still further protection from fire in case the tile and the plaster are torn away by falling parts of the building.

The types of enclosures here illustrated are intended to show the principles of fireproofing columns that should be followed rather than the exact method of encasing them. For instance, a square column may be enclosed in a circular form of casing or a square enclosure may have either square rounded corners.

Some of the shapes of tile generally used for enclosing columns are shown in Figs. 22 and 23. Those illustrated in Fig. 22 are designed for square or rectangular coverings and those in Fig. 23 for circular coverings.

61. Plate-and-Angle Columns.—In Fig. 24 is shown a plan and in Fig. 25 a view of what is known as a plate-and-angle column which has a square enclosure of fireproofing formed of tiles *a*. These tiles are of the shape shown in Fig. 22 (*b*) and the space within the enclosure is filled with concrete. In Fig. 25 is shown the manner in which the tiles are placed to secure broken joints and proper bonding of the tiles, and this method applies to all succeeding enclosures that are illustrated only in plan, as in Figs. 26, 27, 28, 29, and 30.



FIG. 24

62. H Columns.—The **H** column, which is made by the Bethlehem Steel Co., is shown in plan in Fig. 26. This column

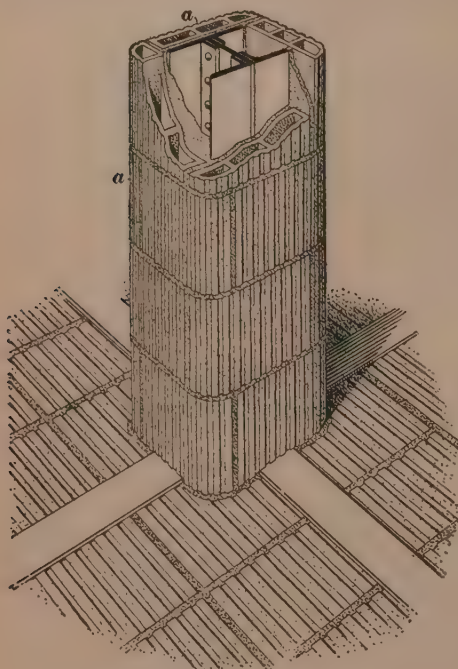


FIG. 25

has a circular enclosure of tiles *a*, which are of the shape shown in Fig. 23 (*a*). In this illustration, plain hollow-tile blocks are placed in the concrete filling around the column to help fill this space, which makes the filling lighter in weight than it would be if of solid concrete.

63. Box Columns.—In Fig. 27 is shown a steel column, commonly known as a *box column*, which is formed of two channels and two plates. The tiles which enclose this column are

of the shape shown in Fig. 22 (*a*), the single-cell tile being a portion cut from one of the same kind of tile as in (*a*).

64. Heavy Box Column.—A heavy box column is shown in Fig. 28. This column is enclosed with tiles of various shapes and thicknesses. Adjoining the column a pipe space is formed by the use of tiles. Three sides *a* of the column are protected by tiles 3 inches thick, while the side *b*, that is protected by means of the pipe space, has a covering of tile only 2 inches thick. These 2-inch tiles are used to form the walls of the pipe space, also to economize in filling in the concrete against two sides of the column.



FIG. 26

The tiles used for this column enclosure are of the shapes shown in Fig. 22 (a) and (b), the form shown in (a) being made either 2 or 3 inches in thickness. The tile shown in (c) is used for the corner members of the pipe-chase enclosure. The tiles with the smaller number of cell units shown in Fig. 28 are formed of regular tiles cut to the size required.

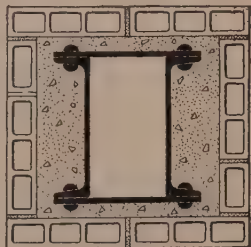


FIG. 27

65. Pipe Spaces or Chases.—If it is desired to conceal the pipes that are to be carried up beside a column, a separate pipe space or chase should be provided for this purpose, as shown in Fig. 28, rather than to attempt to conceal these pipes within the fireproofing of the column. The column itself should be entirely enclosed in hollow tile independent of the pipe chase so that any opening of the walls of the pipe chase, which may become necessary in repairing the pipes, will not expose the column.

66. Cast-Iron Columns.—The method of fireproofing a round cast-iron column by means of hollow tile is shown in Fig. 29. No concrete need be used in this method, as cast iron does not corrode as readily as steel, and consequently does not need to be coated with the cement.

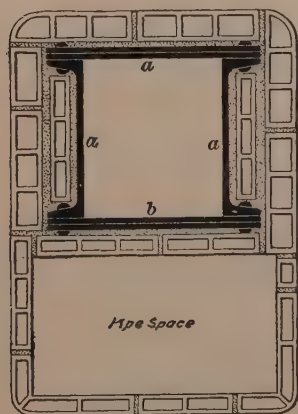


FIG. 28

Square cast-iron columns are not illustrated, but they are treated and covered in a manner similar to the round columns, using the plain regular-shaped tiles shown in Fig. 22 for the purpose.

Solid tile fireproofing blocks, as shown in Fig. 30, are sometimes used for column protection but are less effective than the hollow forms of tile. Hollow blocks are better than solid blocks, although when sufficiently thick the solid blocks are quite as effective for fire-

proofing purposes. The tiles shown in Fig. 23 (*b*) and (*c*) are applied directly against the iron column. The ribs on the inside face of the tile shown in (*c*) are designed to form an air space between the column and the inside shell of the tile.

67. A Fireproof Steel Structure.—Fig. 31 shows the portion of the steel structure previously shown in Figs. 2 and



FIG. 29



FIG. 30

15, after the fireproofing of the steel work has been completed and the exterior walls have been built. The fireproof enclosure for the lower part of the inside channels which form a part

of the exterior wall girders is shown at *a*. The enclosure for the lower part of the interior girders is shown at *b*, the floor arches at *c*, the exterior wall columns at *d*, and the interior columns at *e*. At *f* are shown the wooden timbers called *sleepers*, which are secured to the spot grounds *g* to receive the wooden floor which is to be laid after the plastering has been completed.

TILE PARTITIONS

68. Wall tiles, especially designed to support loads, are used for building walls that are to sustain loads, such as floors and roofs, and are described in the Section entitled *Hollow Tile*. **Partition tiles** are not designed to sustain any weight other than that of the partition itself.

69. Construction of Tile Partitions.—A tile partition is built directly upon the fireproof floor arches or upon the steel beams, and is generally only one story in height. The tiles are laid in cement mortar and the partition is wedged against the floor arches or beams at the ceiling.

The tiles used for partitions are semiporous tile and are made in the sizes shown in Fig. 32.

It is neither practical nor economical to use the 2-inch tile blocks for partitions except in closets or small shafts where

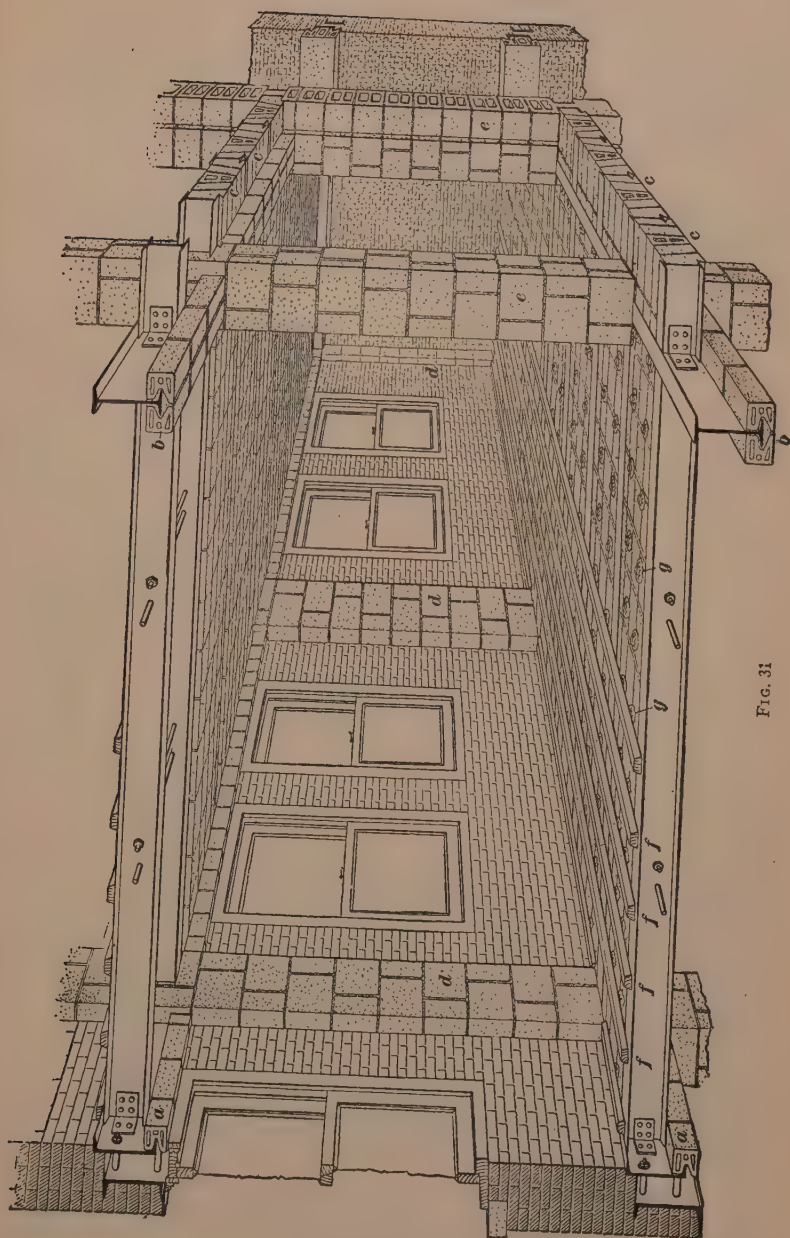


FIG. 31

the lengths and heights of the partitions are short. If they are used for long runs or high ceilings, however, they should be

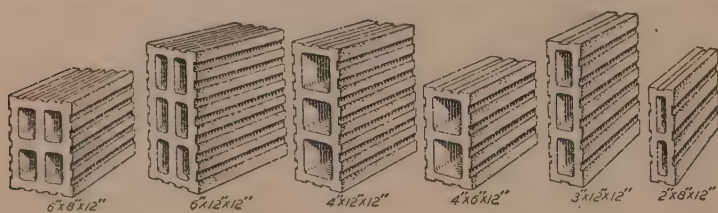


FIG. 32

reinforced with angle irons or wire truss between the courses, as shown in Fig. 33 (a). In (b) is shown a detail of this reinforcement and the manner in which a bend is made for the angle of the wall. Trusses of this character are not required for any tile partition 3 inches or more in thickness unless

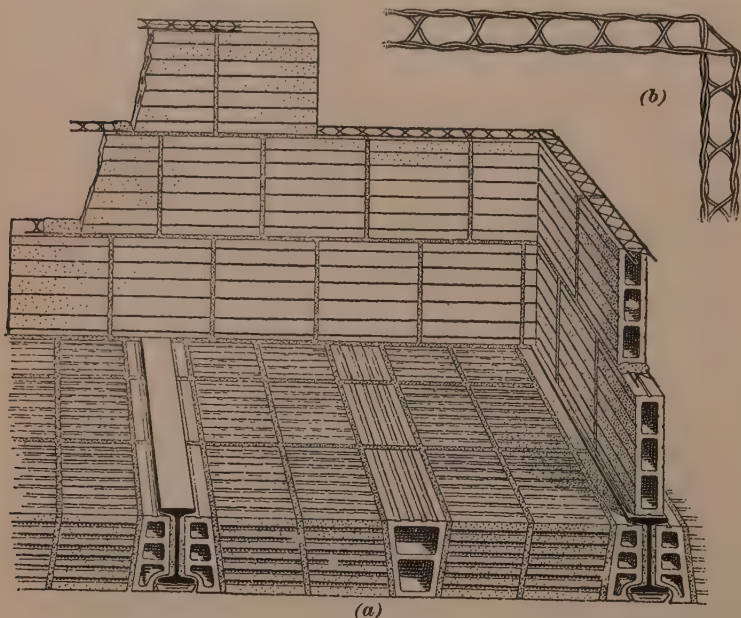


FIG. 33

it is very high or is required to withstand a pressure of some kind. Safe practice is to allow a height of 12 feet for 3-inch

partitions, 16 feet for 4-inch partitions, 20 feet for 6-inch partitions, but the actual requirements of the building codes in cities should always be complied with, regardless of this schedule.

The weight of this semiporous tile in the various thicknesses is shown in Table IX. This is the net weight of the partition

TABLE IX
WEIGHTS OF HOLLOW-TILE PARTITIONS

Thickness of Partition Inches	Weight per Square Foot Pounds
2	10 to 14
3	12 to 16
4	13 to 19
5	20 to 22
6	22 to 23
8	28 to 33

without mortar or plaster, and these amounts should be increased from 6 to 8 pounds per square foot for each plastered surface.

TILE ROOF CONSTRUCTION

70. Book Tile.—Special blocks, known as **book tiles**, shown in Fig. 34, are often used in the construction of pitched roofs. If the roof is to be covered with concrete, tar and felt, or a similar composition, the hard, dense grade of tile may be used. If the covering is to be of slate, the porous grade of book tile should be used, as nails can be driven into it to secure the roof covering in place.

Book tiles are supported by means of **T** irons which are connected to the structural beams of the roof and are laid as shown in Fig. 35. The **T** irons are shown at *a* and the tiles at *b*.

There are two types of book tiles. The one shown in Fig. 34 (*a*) has plain ends *a* and is used for roofs, as just described. This type of tile is known as a *roof tile*. The one

shown in (b) has recessed ends at *a*. This type of tile is grooved, and is known as a *ceiling tile*. The grooves are for

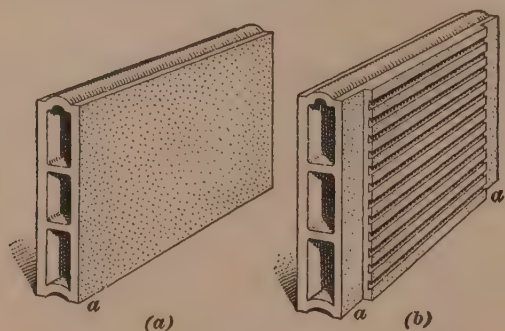


FIG. 34

the purpose of affording a key to the plastering. The recessed ends allow the bottoms of the tile and the T's to be set flush so that the plaster of the ceiling will cover the T's.

Book tiles are set in place and all joints well filled with cement mortar. They should not be used where heavy loads are to be placed upon the roof. These tiles do not afford pro-

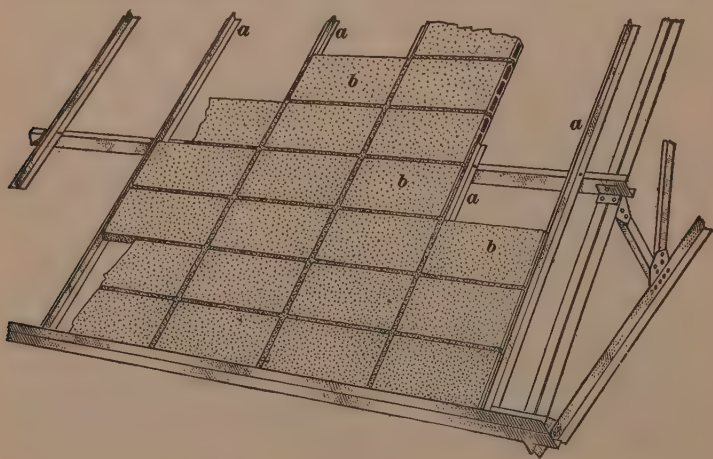


FIG. 35

tection to the steel that supports them and have no fireproofing value. They are, however, incombustible.

71. The sizes and weights of standard book tiles are given in Table X.

TABLE X
SIZES AND WEIGHTS OF BOOK TILES

Roof Tiles		Ceiling Tiles	
Size Inches	Weight Pounds per Square Foot	Size Inches	Weight Pounds per Square Foot
3×12×18	20	3×12×16	20
3×12×20	20	3×12×18	20
3×12×24	20	3×12×20	20
4×12×24	24	3×12×24	20

Government roofing tiles are $\frac{1}{2}$ inch shorter than standard book tiles and $\frac{1}{2}$ inch thinner and are made solid.

72. Flat Roofs.—Flat roofs of hollow tile for fireproof buildings are constructed in much the same way as the floors, except that the beams and girders are often set to give a slight pitch to the roof so that the water will be drained to the conductors. The tiles are so set that the top of the arch will fit closely under the top flange of the roof beams, as shown in

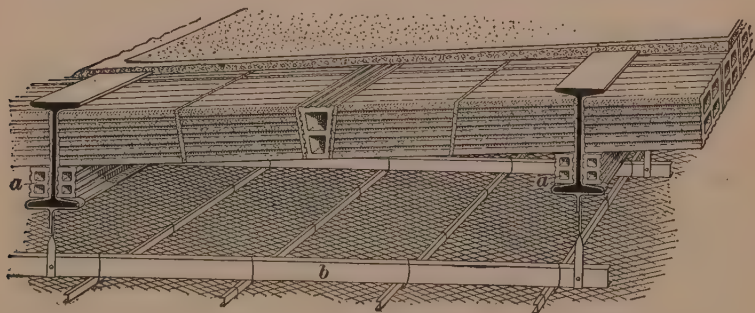


FIG. 36

Figs. 36 and 37. The roof has less of a load to support than the floors, consequently the arches are shallow and the tiles are generally too small to enclose the beams and girders entirely.

In the construction shown in Fig. 36 the webs of the beams are protected by tiles of the form shown at *a*, *a*, which also form bearings for the roof tiles. The bottom flanges of the roof beams are protected by the wire lath and plaster ceiling *b*, but this ceiling, which is level, may be some distance below some of the roof beams, consequently this protection is hardly

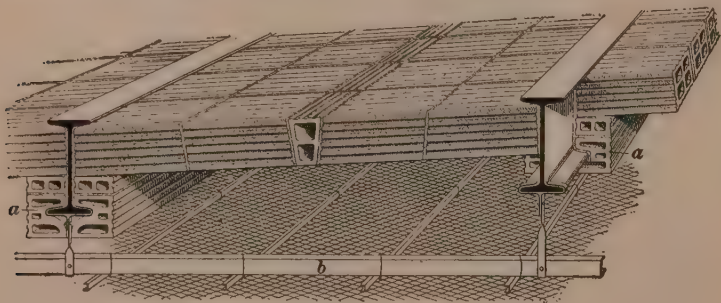


FIG. 37

sufficient. The form of fireproofing shown in Fig. 37 at *a*, *a* should be used if full protection is desired and the hangers for the ceiling placed on the beams before they are enclosed with the fireproofing. When it is desired to form a level ceiling, metal lath and plaster are used and the ceiling is suspended from the roof beams as shown in Figs. 36 and 37.

FIREPROOFING WITH CONCRETE

73. General.—Though structures formed entirely of concrete are in themselves fireproof, they will not be considered here. The construction of concrete floor slabs and the use of concrete in fireproofing columns, beams, and girders are, however, subjects that properly come under the head of fireproofing and will be discussed in the following articles.

It is assumed that the frame of the building, including the columns, girders, and beams, has been designed to carry safely all the floor loads and the fireproofing. The subjects to be discussed are the fireproofing of these columns, girders, and beams, the construction of the concrete floor slabs, and the nature of the materials of which the concrete is made.

The fireproofing of the girders and beams with concrete is, as in the case of terra-cotta fireproofing, so intimately connected with the construction of the floors that these subjects are best considered together. In fact, in many cases of concrete-slab floor construction, the operations of forming the slab and covering the beams and girders are done together, the forms being built for the entire construction and the reinforcement being put in place completely before concrete is poured.

74. Reinforcement of Concrete.—Concrete in itself possesses little tensile strength, but considerable compressive strength. Steel, on the other hand, possesses great tensile strength. When properly used together, these materials form a most valuable building material, the steel supplying the strength which the concrete lacks.

This strength is necessary in the beams, girders, and floor slabs which constitute the floor construction, and the application of this reinforcement to different forms of floor slabs will be shown and described. There are many forms of reinforcement and concrete floor construction that are not shown; but those described illustrate different typical forms of construction.

75. Concrete.—Concrete is not so good a heat retardant as dense or porous tile, but it is a splendid fireproofing as well as structural material when properly mixed and applied. The concrete used for fireproofing purposes may have a coarse aggregate of cinders, gravel, or broken stone of small size, and is known accordingly as **cinder concrete**, **gravel concrete**, or **stone concrete**. If the concrete is to be used to form floor slabs or arches, the gravel or stone aggregate should be used with the cement and sand and this mixture reinforced with steel, as may be required to carry the loads that will rest on the floor.

76. Cinder Concrete.—Cinder concrete, on account of the porous nature and the high resistance of the cinders to destruction by heat, is perhaps the best of all concretes for fireproofing, but as it possesses comparatively little strength,

it is not suitable for structural purposes. Blast furnace slag is often used for the coarse aggregate in concrete as it provides more strength than cinders and has also a high resistance to heat.

Cinders selected for concrete should be free from particles of unburned coal and, where possible, should be ground to a suitable and uniform size. The cinders should be thoroughly mixed with the cement, sand, and water to insure that they are completely covered with this mixture and that all voids in the cinders are filled, to prevent rusting or corrosion of the steel such as often occurs when cinder concrete is used. A wash of cement, sand, and water is sometimes applied to steel work that is to be encased in cinder concrete, and allowed to become dry before the concrete is deposited, to prevent contact with the cinders in the concrete.

Steel columns that are to be encased are sometimes given a coating of cement and sand mortar that is applied with a trowel. This is done to protect the column against corrosion as well as fire.

Cinder concrete is usually made of one part Portland cement, two parts of sand, and five to seven parts of cinders. The materials should be thoroughly mixed together before and after the water has been added and when the concrete is deposited it should be thoroughly tamped so that it will entirely fill the spaces and form a compact mass.

Cinder concrete is used as a filling around columns that are enclosed by tile fireproofing, as shown in Figs. 25, 26, and 27, and also as a filling between wooden sleepers that are placed on fireproof floor arches to receive a wooden floor, as shown in the illustrations of floor construction.

77. Stone and Gravel Concrete.—Gravel concrete or concrete having a coarse aggregate of broken stone is much stronger than cinder concrete, but is more likely to be injured by the extreme heat of a burning building, as the heated surface expands while the remaining parts remain comparatively cool, thus causing unequal expansion that will cause cracking or warping much the same as in brickwork. Extreme heat is

also apt to disintegrate the gravel and stones. For this reason all steel reinforcement in concrete should be located at least $1\frac{1}{2}$ inches from the exposed surface for columns and beams and $\frac{3}{4}$ inch for floor slabs. Water thrown with force upon the surface of heated concrete by means of a hose is liable to tear away this protecting surface and expose the steel directly to the flames.

78. Forms of Reinforcement.—The forms of steel reinforcement may be classified as single loose rods, or bars, fabrics formed by welding or weaving bars or wires together, sheet metal that has been cut and expanded to form a mesh, sheet metal that has portions expanded to form a mesh and other portions formed into ribs, and sheet metal that has been formed into a series of grooves.

Since it is the difference in the form of the reinforcing material that constitutes the different systems, the description of these reinforcing materials will be given in connection with their application to the various floor constructions in which they are employed.

The term bar and rod are used interchangeably in the description of reinforcement for concrete and may apply to round or square forms and plain or deformed shapes.

CONCRETE FLOOR CONSTRUCTION

79. Floors With Loose Steel-Bar Reinforcement.

Bars for reinforcement may be square, round, or oval in section, and either plain, twisted, or deformed. A twisted square bar is shown in the top illustration of Fig. 38 and examples of deformed bars having projections of different shapes are shown in the two lower ones. The object of twisting and deforming the bars is to cause a better adhesion between the steel and the concrete, as the projections and irregularities of the bars prevent the steel from slipping through the hardened concrete when under severe stress. These deformed bars are, however, more expensive than plain ones and in the majority of cases plain bars are used for reinforcing concrete.

80. Bars for reinforcement are usually from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch in diameter and for flat slab construction a large number of small bars is commonly used instead of a small number

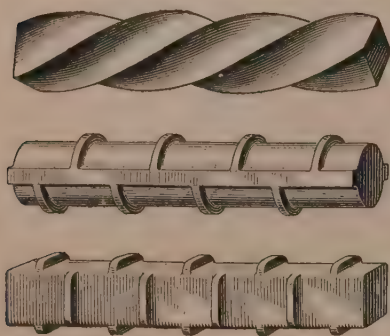


FIG. 38

of large bars. By this arrangement the steel presents a larger surface to which the concrete may adhere, and also the tensile strength is distributed more evenly throughout the mass of concrete.

81. Loose steel bars for reinforcing concrete floor slabs may be placed over the tops of the beams as shown in Fig. 39, between the beams as in Fig. 40, or at the bottoms of the beams as in Fig. 41.

In Fig. 39, the rods *a* are the ones that support the slab, and the rods *b* are provided to counteract the effects of contraction and expansion. These rods are wired together where they cross. The rods *a* are supported on the tops of the beams and are bent down so as to be near the bottom of the slab where

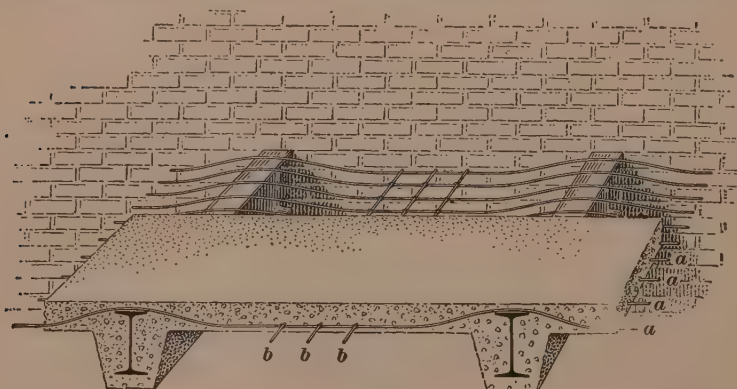


FIG. 39

they will be the most effective. The top of the slab is designed to be an inch or two above the tops of the beams so as to cover

the rods. The rods in Fig. 40 are cut in between the beams and placed so that they will be near the bottom of the slab.



FIG. 40

Expansion rods similar to those shown in the previous figure are shown in this example.

An example of reinforcement at the bottoms of the beams is shown in Fig. 41. The ends of the rods may rest on the bottom flanges of the beams or may be turned up as shown in the figure. Cinder concrete or plain cinders are used to fill the space above the slab. This filling is brought up to the level of the tops of the beams so that the floor sleepers can rest upon it.

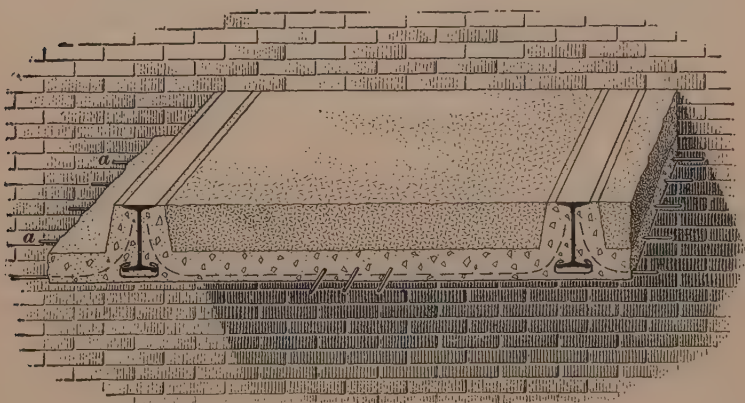


FIG. 41

Wire mesh is sometimes wrapped around the bottom flanges of the beams to afford a good grip for the concrete beneath the

beams. The object of making a slab of this description is that plaster may be applied directly to the surface and a flat ceiling obtained. With the other slabs shown it will be necessary to hang a ceiling if a flat ceiling is required. In plastering on a concrete surface such as the under surface of the slab in Fig. 41, a patent plaster should be used that is guaranteed to adhere to the cement.

82. Another example of the arrangement of reinforcement at the bottoms of the beams is shown in Fig. 42. The reinforcing bars *a* have bearings on the bottom flanges of the steel beams, as shown at *b*. Sheet-metal forms *c* are used and

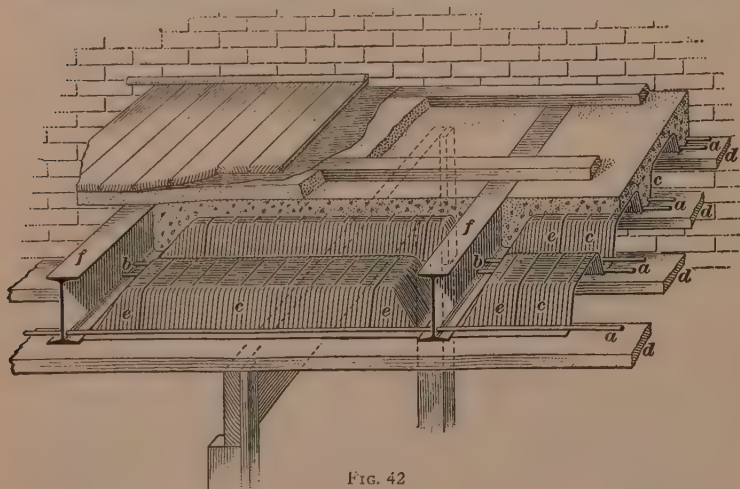


FIG. 42

rest on the wooden centering boards *d*. When the concrete is poured, the concrete beams and slabs are formed at the one operation. These metal forms have special closed end members as shown at *e*, which permit of the sides of the steel beams being covered with concrete as shown. After the concrete has become hard, the centering and steel forms are removed and the ceiling that is exposed consists of concrete beams and slabs. There are several modifications of this form of construction but they are similar in principle.

If the bottoms of the beams *f* are to be protected, they must be enclosed in metal lath before the wooden centering is

erected. After the floor construction has been completed and the centering removed, this metal lath must be coated with a cement mortar.

83. Floors With Welded or Woven Reinforcement.

Reinforcement.—In reinforced-concrete work, the principal reinforcing bars extend from one bearing or support to another and cross-bars are run at an angle to the main bars.

The placing of these bars and cross-bars in the construction requires considerable time and they are liable to be displaced when the concrete is poured. As a remedy for this condition a form of reinforcement has been placed on the market in which the main reinforcing bars are rigidly connected with the cross-bars. These forms of reinforcement are sometimes called *fabrics*, and are made in different ways, as shown in Fig. 43. In (a) the bars are welded together by electricity; in (b) the cross-bars are formed of a lighter wire that is twisted around the principal bars. In (c)

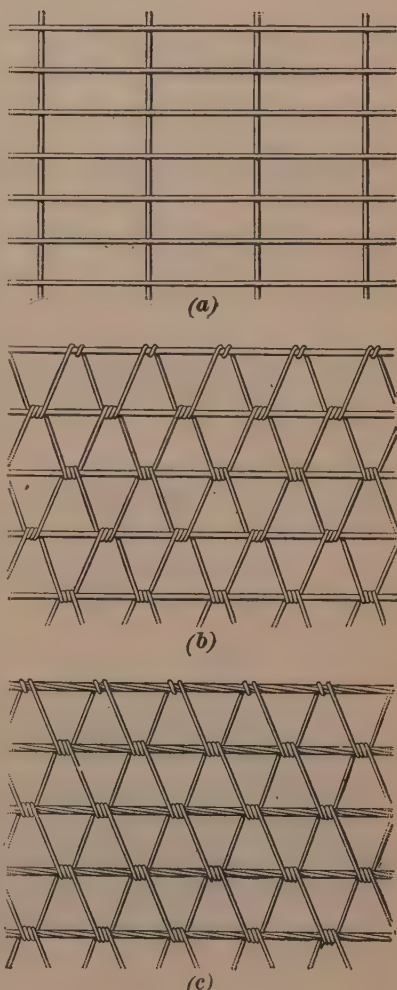


FIG. 43

the principal bars consist of several strands of wire and the cross-wires are wound around them. In b and c the cross-bars run diagonally.

84. To fulfil the requirements of a reinforcing material, these fabrics should have a large number of small strands rather than a small number of large ones. There is on the other hand greater danger attending the use of small strands on account of corrosion of the material and the greater difficulty of keeping the light reinforcing material from becoming displaced when pouring the concrete.

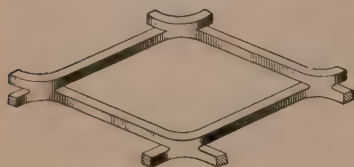


FIG. 44

85. **Expanded - Metal Reinforcement.** — Another widely used form of reinforcement is known as *expanded metal*. There are several types of this kind of reinforcement. One type consists of a heavy-gauge metal which is expanded to form large openings, or meshes, as shown in Fig. 44, and, on account of this open character, requires wooden centering on which the expanded metal may be placed and the concrete poured. The other type, shown in Fig. 45, is formed of a lighter-gauge sheet metal. The mesh is of a smaller size and ribs are formed at intervals to provide the strength that is necessary to carry the loads



FIG. 45

between the bearing surfaces. On account of the small mesh of this form of reinforcement only enough concrete can pass through to form a clinch with the metal, and the ribs stiffen the sheets so that they are self-sustaining for spans not exceeding 5 feet. The advantage of this kind of reinforcement is that for

these short spans no support or centering is required. For spans of 6 to 8 feet, a temporary brace or support under the middle is all that is required.

The one objection to this form of reinforcement is that the metal is not embedded in the concrete slab and must be protected by means of a coating of cement mortar applied after the concrete is set.

86. A form of reinforcement made of expanded metal is shown in Fig. 46. This material has the main ribs *a* heavier than the cross-ribs *b*. The main ribs provide the strength necessary for the reinforcement, while the cross-ribs act as spacing bars and also as shrinkage bars when the reinforcement is embedded in the concrete.

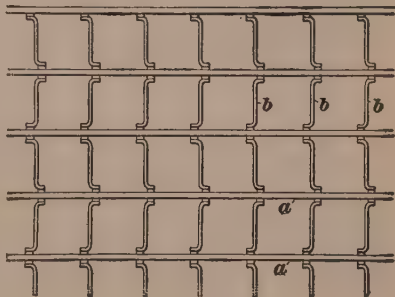


FIG. 46

87. Arched Floor Construction.—The kinds of reinforcement shown in Fig. 43 may be used in the formation of

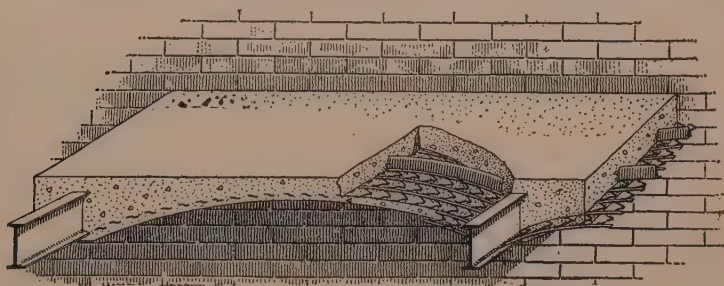


FIG. 47

what are known as concrete arches, such as that shown in Fig. 47. For this purpose, however, the heavy-gauge fabrics and those having ribs such as shown in Fig. 45 are usually formed at the mill into the shape of arch desired, and are set in between the beams.

88. Floors on Self-Centering Sheet Metal.—In Fig. 48 is shown a form of sheet-metal centering for floors. It is placed directly on the tops of the steel beams. The concrete *a*

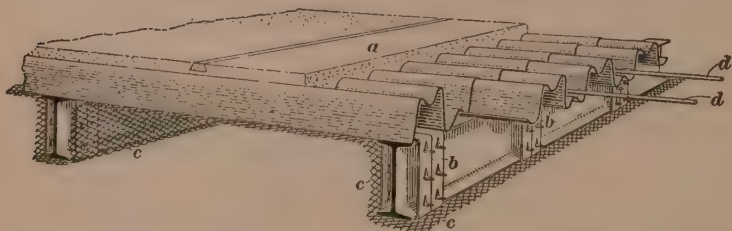


FIG. 48

is poured into the channels on the upper side of the centering and to a level of about 1 inch above the top of the centering. The centering is not covered with concrete on the under side, hence the metal is exposed to the action of fire. If a plastered ceiling is desired it must be formed by attaching metal lath to the under surface of the centering and around the beams. At *b* are shown devices designed to hold in place the metal lath *c* that is wrapped around the steel beams. This ceiling affords some protection for the under surface of the sheet metal and the steel beams but the construction cannot be considered as absolutely fireproof.

The device shown in Fig. 49 is sometimes used to attach the ceiling lath to the sheet-metal centering. It consists of small pointed pieces of sheet iron such as shown at *a*. They are placed between two adjacent sheets of metal centering and project downwards as shown at *b*. The points *b* project through the lath and are bent up around the strands of the lath, thus securing it in place.

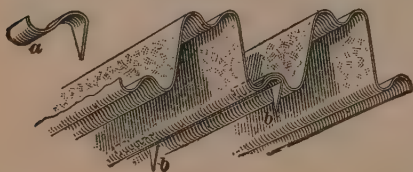


FIG. 49

When especially heavy floor loads are to be sustained with the kind of reinforcement described, reinforcing bars should be placed in each of the forms as shown in Fig. 48 at *d*.

89. The form of centering shown in Fig. 50 (a) consists of a sheet of metal bent so as to form a series of dovetailed grooves on both sides of the sheet as shown at *a*. The concrete of the floor slab fills the upper grooves and forms a sort of key which holds it firmly to the metal. Plastering will adhere to

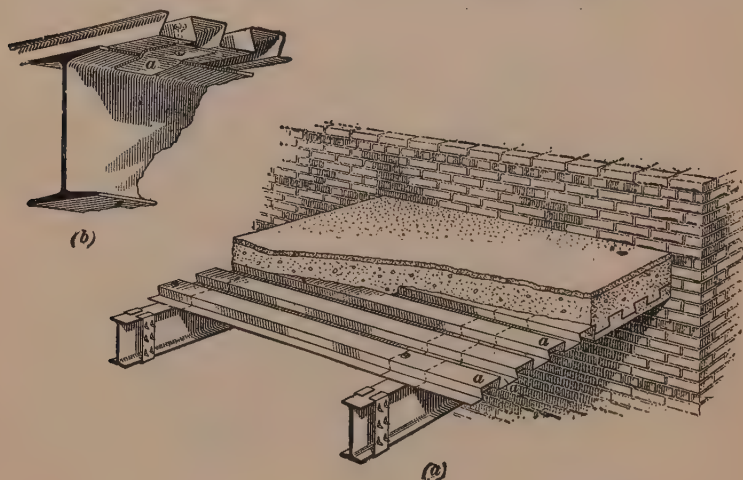


FIG. 50

the under side of the sheet, as the grooves are of a dovetailed shape. When plastering is applied the metal is protected from fire, otherwise the under side of the steel will be exposed to the flames. The method of securing this form of centering to the beams is illustrated at *a* in (b).

FIREPROOFING BEAMS AND GIRDERS WITH CONCRETE

90. Concrete fireproofing of steel beams and girders is generally installed at the same time as the concrete floor slabs. When properly applied, the concrete not only affords protection from fire but protects the beams from corrosion. For complete fire protection, the webs and flanges of the beams and girders must be encased in concrete. If the concrete is of sufficient thickness, that is, not less than 2 inches thick, it will hold securely around the lower flange of beams without

the aid of steel reinforcement. Nevertheless it is good practice and gives greater security from failure during a fire, to encase the lower flanges of all beams in metal fabric or expanded metal to afford a key for the concrete. In Fig. 51 is shown a steel beam with the lower flange wrapped in a metal fabric. This fabric extends across the bottom of the beam, as at *a*, and

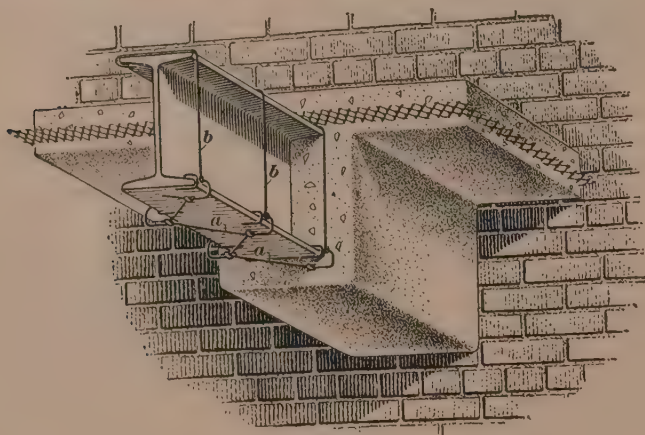


FIG. 51

extends vertically from flange to flange, as at *b*, leaving the space between the reinforcement and the web of the beam to be filled with concrete. Care should be taken in using reinforcement for the concrete on the under side of the beam, to keep it $\frac{3}{4}$ inch to 1 inch away from the flange so that the concrete may surround the reinforcement and obtain a firm hold on it.

FIREPROOFING COLUMNS WITH CONCRETE

91. Where concrete is applied for the purpose of fireproofing only and where its strength is not essential, it is best made with cinders, as cinder concrete is not only one of the best fire-resisting substances but is the lightest form of concrete.

92. In some cases forms are set up around the columns, forming a space of 2 or 3 inches outside them. These forms may be circular, square, or rectangular in shape, as may be convenient. The concrete is then poured into the forms,

entirely burying the steel columns. The forms are removed and the concrete is generally finished with a plaster finish.

93. Another method is to form a square or circular enclosure of metal furring and lath around the column. Concrete is poured into the space between the lathing and the column. Fig. 52 illustrates a square enclosure, the concrete filling being shown at *a*. The concrete *b* that projects through the metal lath in this construction affords an excellent key for the finishing coat of wall plaster. The concrete should be made wet enough to run into all corners and angles so as thoroughly

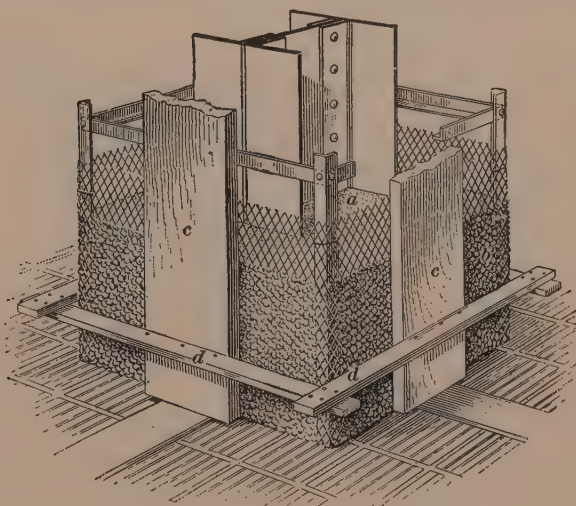


FIG. 52

to bury the steel work. The upright planks *c* are placed against the lath to keep it from bulging outwards when the concrete is poured. These planks are held in place by the braces *d*.

94. Use of the Cement Gun.—A method of fireproofing that is very successful and which requires no forms is to apply cement mortar to the surfaces of the steel by means of a *cement gun*, which is an apparatus that shoots thin cement mortar in a stream against the columns, beams, etc., and

causes it to penetrate all cracks and cavities. Columns have been coated with $1\frac{1}{2}$ inches of cement mortar by this means and thus successfully protected from injury by fire as well as corrosion. Cement is applied in that way by companies that make a specialty of that kind of work and own their own implements.

FIREPROOFING WITH BRICK

95. Experience shows that brick is probably as good a material as can be found from the fireproofing standpoint, and that it will withstand the heat from an intense fire for a long time without failing.

96. Brick Floor Arches.—Brick arches are not used to any great extent now in fireproofing on account of their weight and expensiveness. The brick arch is perhaps the strongest type of arch for the span it occupies, with the possible exception of the concrete arch. Owing to its weight, the brick arch requires the strongest and heaviest framework and is therefore the most expensive construction.

The brick used in floor arches should be hard and well burned and the joints filled with strong cement grout. The bricks in one row should break joints with those in the rows adjoining, and in case the arch is a double rowlock arch the joints of the upper rowlock should break joints with those of the lower rowlock. The most favorable span for a brick arch is between 4 and 6 feet and the rise should be about $\frac{1}{8}$ of the span, or $1\frac{1}{2}$ inches to the foot. Arches of over 6 feet span should be formed of two rowlocks. To protect the lower flange of the I beams, brick arches should be sprung from heavy terra-cotta skewbacks with lips meeting at the center of the flange.

97. Brick Enclosures for Steel Columns.—The steel wall girders and columns in exterior walls are generally enclosed with brick. In structures having floor arches of brick, the interior steel columns are frequently enclosed by a 4-inch brick wall instead of with terra cotta.

These brick enclosures for columns form a very effective protection, and the concrete filling, previously described under Fireproofing Steel and Iron Columns With Terra Cotta, is then omitted.

FIREPROOFING WITH METAL LATH AND PLASTER

98. Protecting Beams and Girders.—Metal furring, lathing, and plaster are used as a protection for beams, girders, columns, etc. There is a difference, however, between pro-

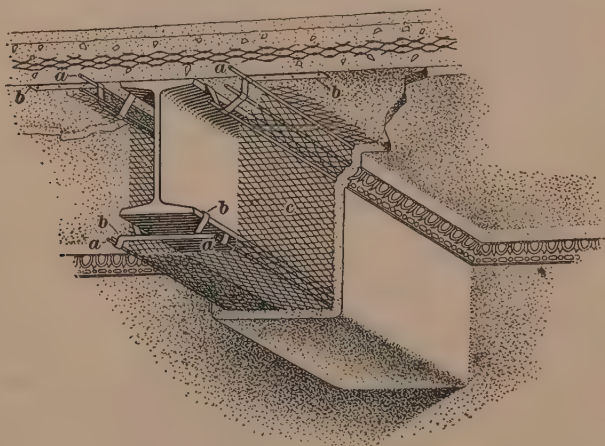


FIG. 53

tecting steel work and fireproofing it, which it will be well to keep in mind. A *protected* beam encased in wire lathing and plastering is not protected from corrosion and the plaster work with which it may be encased is not likely to survive a very hot or prolonged fire. A *fireproofed* beam is protected from both corrosion and fire.

A protected beam is shown in Fig. 53. Steel furring bars *a* are secured at intervals to the straps *b*, and these are fastened to the steel beam and ceiling construction as shown. The metal lath *c* is stretched over the frame thus provided and the furring bars, straps, and lath are tied together by the use of steel wire.

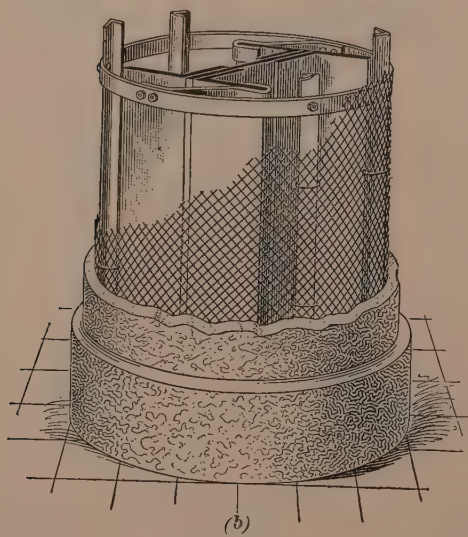
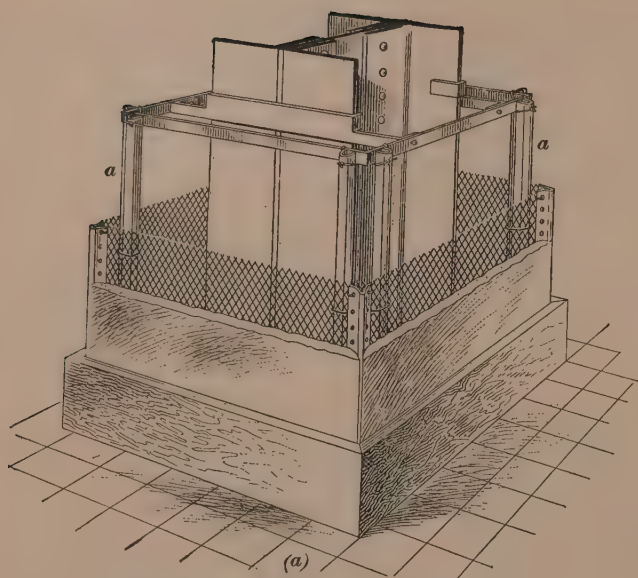


FIG. 54

Three coats of plaster are applied to this lath and the protection is completed.

99. Protecting Steel Columns.—In Fig. 54 (a) is shown one method of protecting a column by means of a square enclosure of lath and plaster. The wire lath is fastened to the ribs *a*, which are secured to the column in such a way as to provide a space between the wire lath and the column. In (b) is shown a somewhat similar method of protecting a column by means of a cylindrical enclosure.

FIREPROOF PARTITIONS

100. Materials.—Fireproof partitions are used to divide a floor into separate rooms, halls, etc., so that fire cannot spread from room to room. They are constructed of non-combustible materials such as terra cotta and brick, or of metal lath and plaster. Partitions of terra-cotta tile have already been described, and the construction of fireproof partitions using metal lath and plaster will now be considered.

The principal material used in the construction of these partitions is steel, in the shape of studs and metal lath. This material is buried in mortar or plaster, or else is covered by them, and is thus protected from destruction by flames. It is the mortar or plaster that gives these partitions the fireproof value that they possess, while the metal studs and lathing simply hold the mortar in place.

101. Metal Studding.—Studding for fireproof lath and plaster partitions may be of rolled steel in the form of standard angles and channels or of sheet steel which is bent into shapes similar to rolled-steel studding. In Fig. 55 are shown the common forms of *rolled-steel studding*. In (a) is an angle and in (b) a channel, which are the principal forms employed.

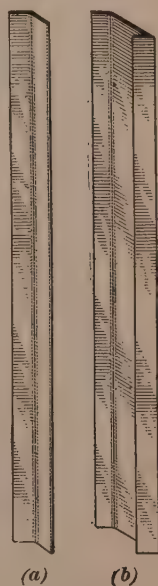


FIG. 55

In Fig. 56 are shown the standard forms of *sheet-metal studding*. That shown in (a) is a *channel stud*; in (b), an *I stud*; in (c), a *T stud*; in (d), a *U stud*; and in (e), an *angle stud*. A *channel socket strip* (f) is made to hold the

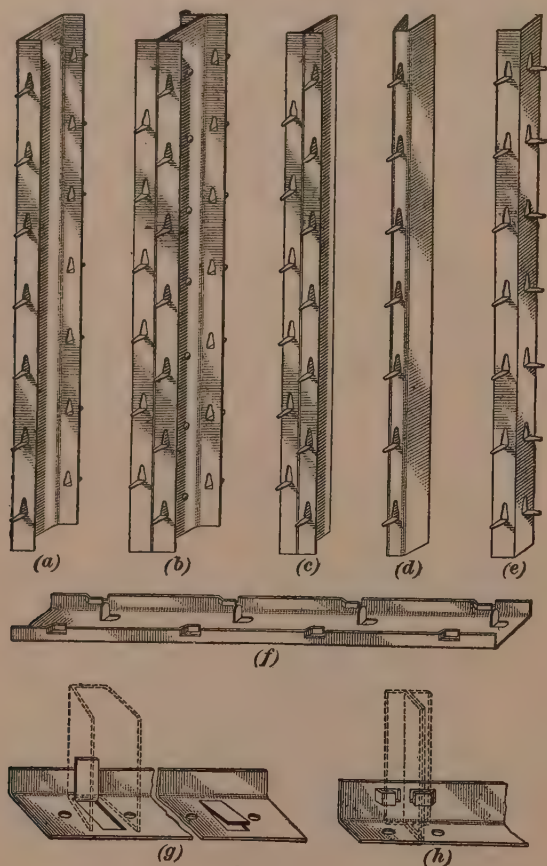


FIG. 56

channel and I studs at the ceiling and the floor, the socket strip being secured to the ceiling and floor by the use of expansion bolts or lagscrews. In (g) is shown a *socket strip* designed to receive the U stud; in (h), a *socket strip* for holding an I stud. These last two are in the form of angles.

There are other devices for securing the studs to the ceiling and floor, such as the one shown in Fig. 57. Brackets *a* are slipped on the ends of the T stud, and the brackets are secured to the ceiling and floor by means of nails.

Fig. 58 shows a rolled-steel channel stud and the manner in which the ends are treated to provide suitable connections with the ceiling and the floor construction. The connection at the top of the stud consists of an angle riveted to the stud, while at the bottom the channel is bent to a right angle to form the connection. Both of these connections have holes to receive expansion bolts or screws which may be used as a means of fastening the stud to the ceiling and the floor construction.

The simplest method of securing studding to concrete slabs is to cut shallow holes of the shape of the stud in the ceiling and floor and to spring the studs into them. The studs will then extend into the concrete for about $\frac{1}{4}$ inch on each end, and when the wire lath is secured to the studs they will be held rigidly in place

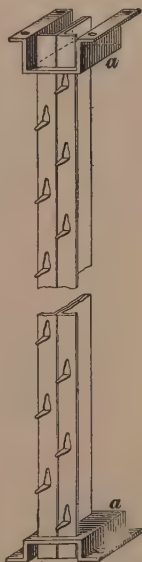


FIG. 57

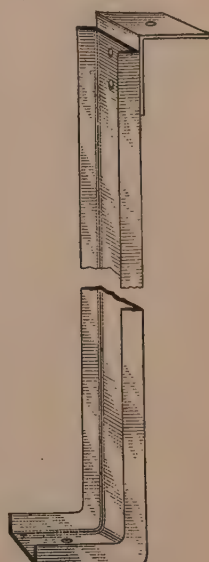


FIG. 58

102. Securing Metal Lath to the Studs.—It will be observed that the sheet-metal studding is provided with prongs which are punched out of the thin metal of which the studs are made. These prongs project and are designed to hold the metal lath in place. Sheets of metal lath are placed against the studs and the prongs project through the metal lath and are hammered flat so as to enclose one or more strands of the lath, thus holding it securely. Rolled-metal studs are not pro-

vided with prongs and the metal lath must be fastened to them with annealed wire, which is a wire that will stand considerable bending before it will break.

METAL LATH

103. Types of Lath.—Metal lath is very similar in form to some of the reinforcing metal fabrics used in floor construction, but is lighter in weight, and is used on ceilings and

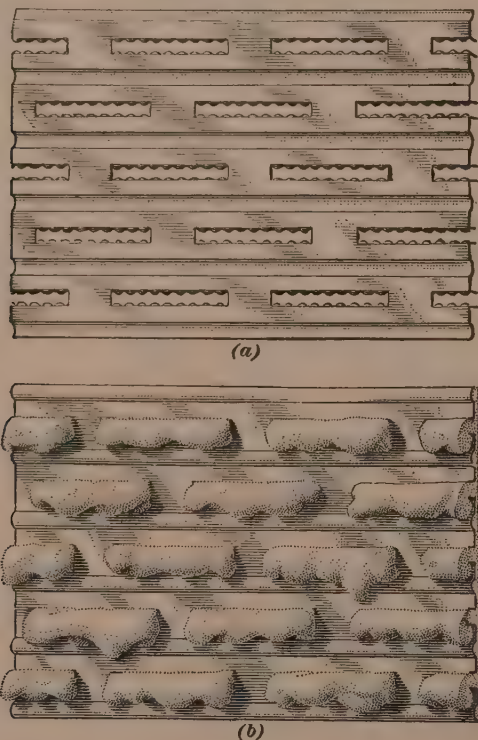


FIG. 59

partitions as a groundwork or key for plastering. In fireproof partitions metal lath only should be used.

There are two principal types of metal lath, classed according to the proportion of openings in them. One type is *per-*

forated sheet-metal lath, in which the area of the openings is small in comparison with the solid surface. The other type is formed by *expanded-metal* or *woven-metal* fabric, in which the area of the openings is greater than the area of the solid part.

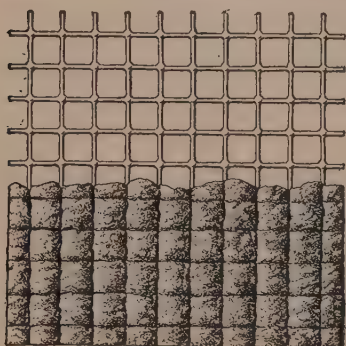


FIG. 60

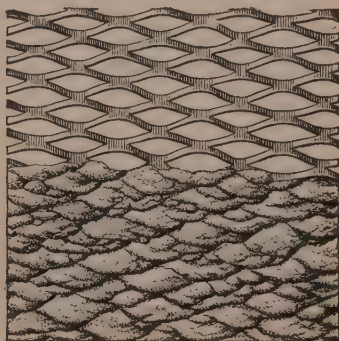
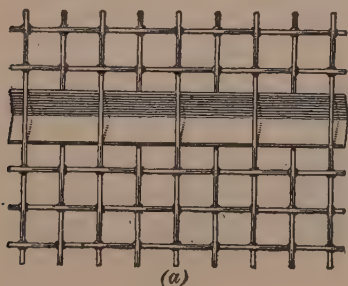


FIG. 61

A lath that has a small area of perforations, as that shown in Fig. 59 (a), will be only partly covered on the back surface by the plaster, as shown in (b), while a lath with large perforations permits more plaster to go through and cover the mesh, thus protecting the metal from fire and rust. This type is illustrated in Figs. 60 and 61. The type of lath with the large proportion



(a)



(b)

FIG. 62

of openings is made either of a woven mesh, as in the case of the Roebling wire lath, Fig. 60, or of expanded metal, Fig. 61, of which there are several different forms on the market.

104. Protecting Metal Lath.—Metal lath that is fully embedded in plaster is in little danger of corroding. It is

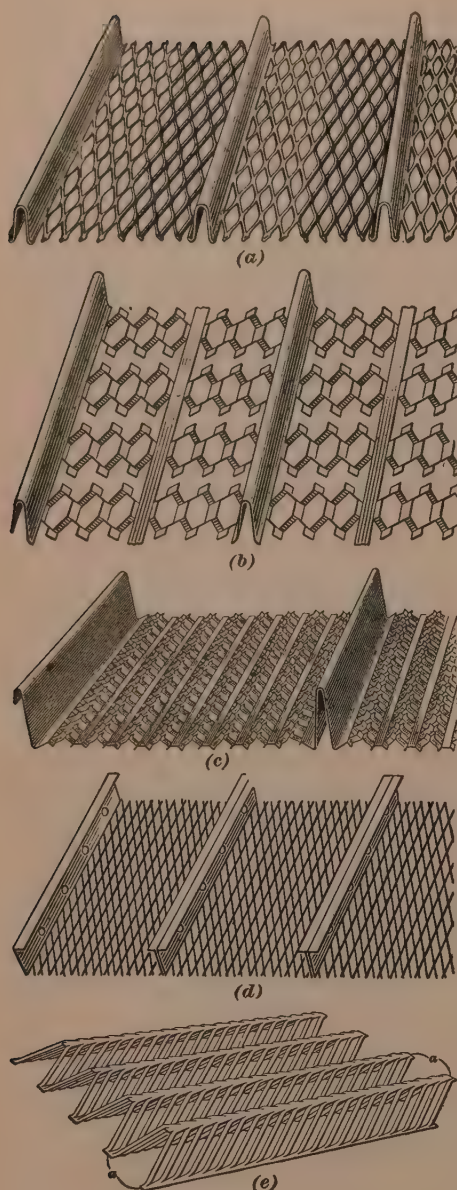


FIG. 63

nevertheless well for all metal lath to be either painted or galvanized to protect it from corroding, since it is never certain that the back of the lath will be entirely covered with plaster. Lath of the sheet-metal type, the back of which is always partly exposed to the air, must be especially well protected. This protection consists of galvanizing, or covering with a coating of zinc; of painting with oil paint; of japanning, a covering that is baked on the metal; besides other methods, all of which are designed to prevent corrosion of the metal.

105. Reinforced Metal Lath.—Metal lath is reinforced where special rigidity is required, as where the studding or furring is widely separated. The reinforcement is also used as a substitute for studding in certain cases.

Woven-metal lath is stiffened by means of **V** stiffeners, which are attached to the lath by means of clips or are woven into the fabric. Solid round bars are also sometimes used for the same purpose. The metal lath shown in Fig. 62 (*a*) shows **V**-shaped stiffeners. The **V** rib projects about $\frac{3}{8}$ inch above the back of the lath, as shown in (*b*), which is the rear view of a plastered section of the lath.

Expanded metal is reinforced by forming **V** ribs in the sheet of metal of which the lath is made, as in Fig. 63 (*a*), (*b*), and (*c*); with **T**-shaped ribs, as in (*d*), or by bending the lath as shown in (*e*). These rein-

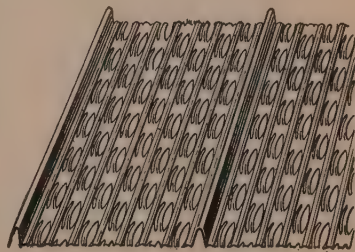


FIG. 64

forcements stiffen the lath considerably and with the assistance of a temporary wood bracing they are stiff enough in small partitions to take plastering without the use of studding.

Sheet-metal lath is reinforced by having **V** ribs stamped in the sheets as shown in Fig. 64.

CONSTRUCTION OF PARTITIONS

106. Solid Partitions.—Fireproof partitions are built either solid or hollow. A solid partition is built of reinforced lath or of steel studs with one layer of lath attached, and this construction is enclosed in a solid mass of plaster. The usual thickness of solid partitions is from $1\frac{3}{4}$ inches to 3 inches. The size and weight of the studding or lath are usually governed by the height of the partition as well as its length. For instance, a partition made with 2-inch studs will not be rigid if more than 12 feet in height and 15 feet in length. If the partition is larger than these dimensions it will be necessary to use larger studding. Studding placed 12 inches apart on centers makes a stiffer partition than when 16 inches on centers.

107. Solid partitions formed with rolled-steel studs, metal lath, and plaster, should be made as follows:

The studding should be of $\frac{3}{4}$ -inch steel channels for a partition having a height of 10 feet or less, and of 1-inch channels

TABLE XI
CORR-MESH PARTITIONS

Height of Partition Feet	Gauge Number of Lath	Thickness of Partition Inches
Up to 8	28	1 $\frac{3}{4}$
8 to 12	28	2
12 to 13	26	2
13 to 14	26	2 $\frac{1}{4}$
14 to 15	26	2 $\frac{1}{2}$
15 to 16	24	2 $\frac{1}{2}$
16 to 17	24	2 $\frac{3}{4}$
17 to 18	24	3

If over 18 feet in height, uprights of small angles, I's, or channels should be provided, and the Corr-Mesh sheets placed horizontally.

for partitions over 10 feet in height. Studding should be spaced not to exceed 16 inches on centers and be set into or securely anchored to the floor and ceiling construction.

TABLE XII
PARTITIONS REINFORCED WITH HY-RIB

Partitions		Hy-Rib	
Height Feet	Thickness Inches	Gauge Number	Reinforcement Inches
Up to 10	1 $\frac{3}{4}$	28	1 $\frac{3}{8}$
12	2	26	1 $\frac{3}{8}$
		28	1 $\frac{5}{8}$
14	2 $\frac{1}{4}$	24	1 $\frac{3}{8}$
		26	1 $\frac{5}{8}$
16	2 $\frac{1}{2}$	26	1 $\frac{5}{8}$
18	2 $\frac{3}{4}$	24	1 $\frac{5}{8}$
20	3	22	1 $\frac{5}{8}$

Metal lath should be not less than No. 27 gauge and should be securely tied to one side of the studding with No. 18 gauge annealed wire.

108. A form of metal lath called **Corr Mesh** is illustrated in Fig. 63 (*b*), and Table XI has been compiled by the manufacturers to indicate the gauge of this form of metal lath that should be used for solid partitions of various heights, also the proper thickness for the finished plastered partition.

A form of metal lath known as **Hy-Rib**, shown in Fig. 63 (*c*), is also used for solid plaster partitions. Table XII indicates the gauge of metal and thickness of partitions for various heights according to the recommendations made by the manufacturers of this lath. In the table, under the heading Reinforcement, Inches, are given the sizes of the **V** ribs in a direction perpendicular to the face of the lath.

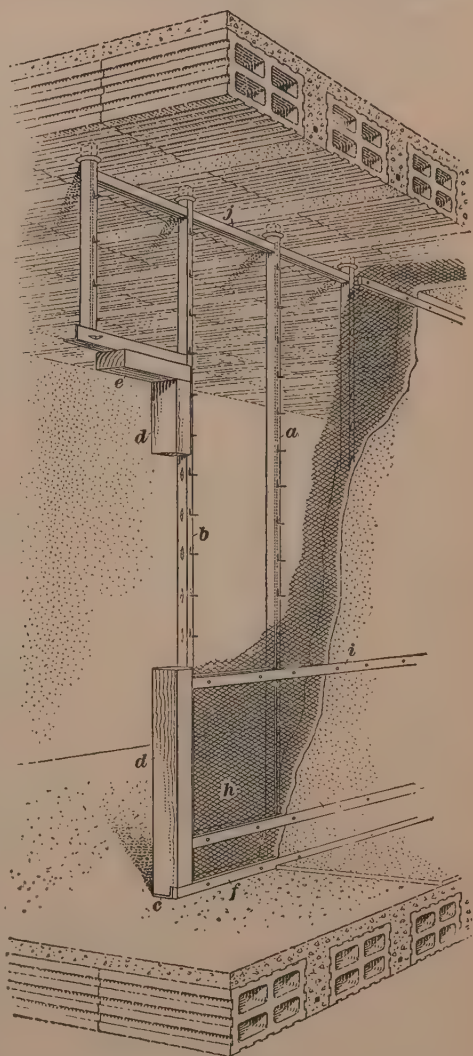


FIG. 65

109. Construction of Solid Partitions.—Examples of solid partitions, with details of their construction, are shown in



FIG. 66

the accompanying figures. In Fig. 65 the use of a sheet-metal studding with prongs is shown. At *a* is shown a U stud and an angle stud at *b* forms the jamb of the door. The head of the door is also an angle section. These studs are connected with the floor by means of an angle-shaped socket strip *c*, and are let into holes cut into the ceiling. Where these holes are larger than the studs the extra space is filled with cement mortar.

The metal lath is stretched over the surface of the studs and the prongs are hammered flat, enclosing one or more strands of the lath, and securely holding it in place.

Wood bucks *d* and *e* are secured to the angle studs by means of screws or bolts. The projecting prongs on the jamb side of the angle studs *b* are hammered flat so that the buck will fit close to the studs. Grounds to which the baseboards are nailed are shown at *f* and *g*. These consist of $\frac{3}{4}$ -inch or $\frac{7}{8}$ -inch wooden strips placed on each side of the metal lath *h* and screwed or nailed together. Similar grounds are shown at *i* and *j* to provide nailing for a chair rail and picture molding.

Fig. 66 shows a horizontal section through a portion of a solid partition such as shown in Fig. 65. The U stud is shown at *a*, Fig. 66, the angle stud forming the door jamb at *b*, and the metal lath at *c*. A buck *d* is screwed to the angle stud,

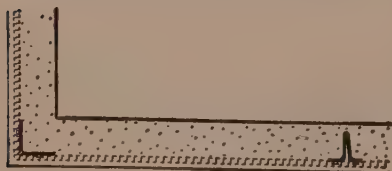


FIG. 67

the door jamb *e* and the trim *f* are all nailed to the buck.

Fig. 67, which is also a horizontal section, shows the use of an angle stud at the corner of a wall. The

prongs occur on both sides of the angle so as to afford a strong grip on the metal lath.

110. Similar partitions can be formed by the use of rolled-steel studs, as is shown in Fig. 68. The principal difference is that no socket is used, the ends of the studs being bent over and fastened to the ceiling and floor construction. Braces are

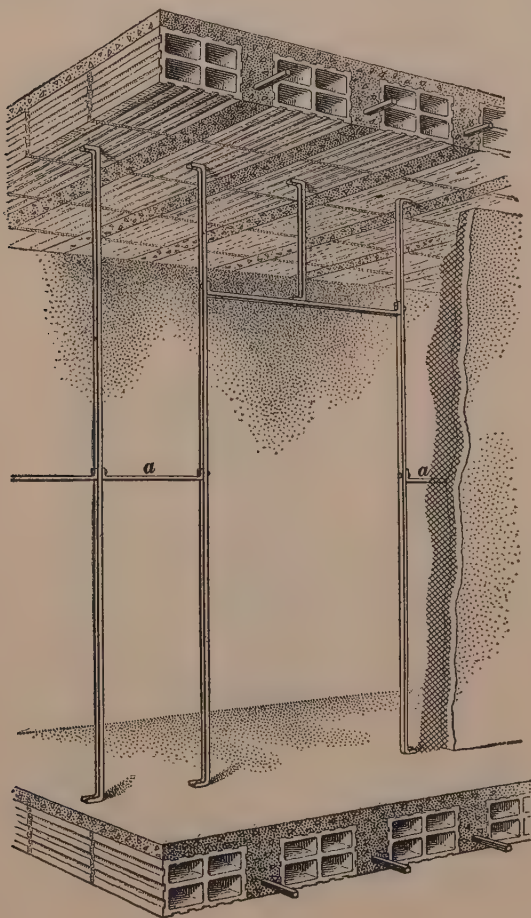


FIG. 68

shown at *a, a* for stiffening the studding. Grounds and bucks are attached to these partitions in the same manner as described in the previous article. The lathing is secured to the studs by tying with annealed wire.

111. A partition formed with *Trussit*, a form of expanded metal shown in Fig. 63 (*e*), is shown in Fig. 69. This material fits into a socket consisting of a metal angle, made of expanded

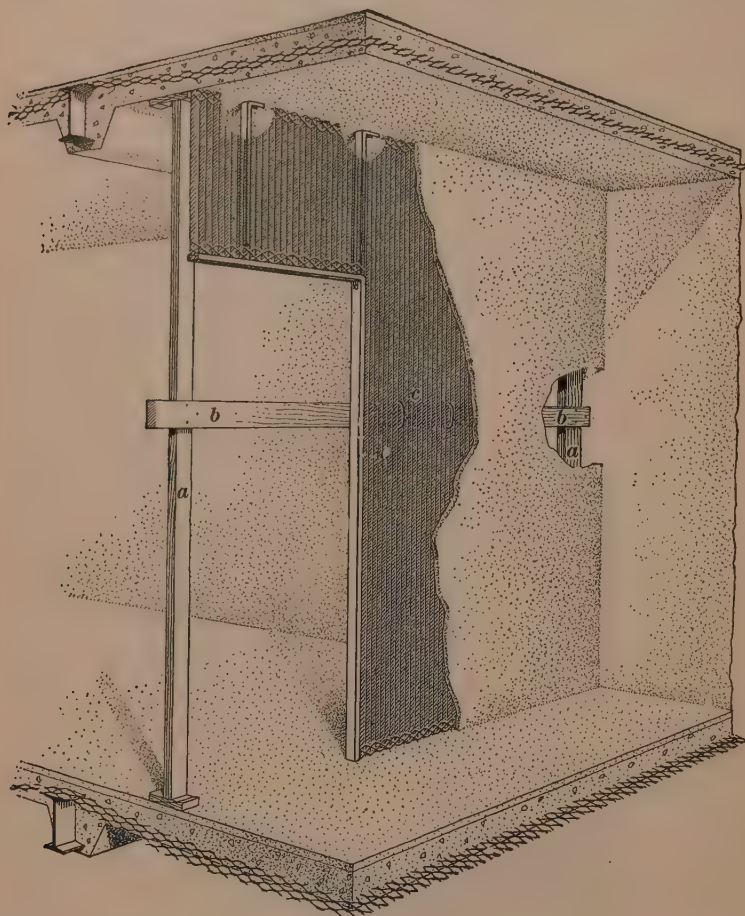


FIG. 69

metal, which is secured to the floor and wired to the *Trussit*. A similar socket holds it at the ceiling. Door jambs are formed of rolled channels to which wooden bucks are fastened. Grounds are wired or else secured to the *Trussit* by nailing.

While one side of a partition is being plastered, a simple form of bracing is placed against the other side. This may consist of uprights *a* to which cross-braces *b* are nailed. These cross-braces should be not more than 5 feet apart and the Trussit should be placed with the ribs at right angles to the cross-bracing. The Trussit should be temporarily wired to the bracing, as at *c*. When the plastering has set on one side, the bracing is removed and placed against the plastered side and the opposite side plastered. Ordinarily this partition is made about 2 inches in thickness but by the addition of more coatings of plaster can be made $3\frac{1}{2}$ inches thick.

112. A method of forming a fireproof door jamb in which no wood is used is shown in Fig. 70. A $1\frac{1}{2}$ -inch channel stud *a* runs to the ceiling on each side of the door and a 2-inch channel *b* is fastened to it to form a buck. A jamb *c*, of sheet metal,

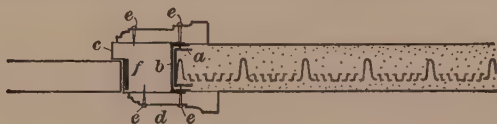


FIG. 70

is fastened to the channel buck and a sheet-metal trim *d* is fastened to the buck and jamb by screws *e*. This holds the trim firmly in place. The jamb is reinforced at the points where the hinges and locks occur by strips of metal *f*. This treatment makes an absolutely incombustible and practically fireproof door jamb and trim.

113. All the solid partitions shown are what are called self-supporting partitions, which do not carry any load besides their own weight.

114. Hollow Partitions.—Hollow fireproof partitions are formed with rolled-steel studding in the form of angles or channels, as shown in Fig. 55, and with sheet-metal studs of shapes shown in Fig. 56. These partitions are generally self-supporting, but, by using I studs and channel sections of sufficient size and thickness, they may be made of sufficient strength to support light loads. The construction of hollow partitions is

practically the same as that of wood-and-plaster partitions except that the studs and lath are of metal.

The studs are secured to the ceiling and floor in a manner similar to that described for the studs in solid partitions.

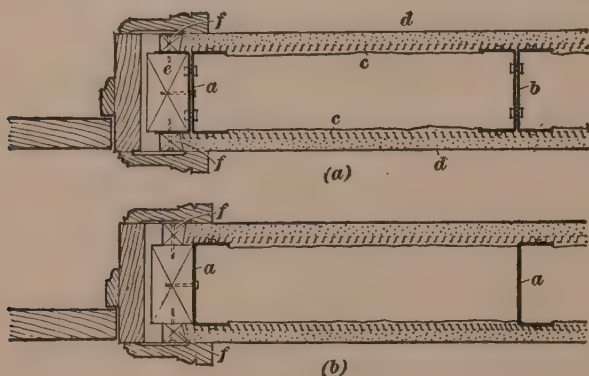


FIG. 71

Grounds are set in between the studs and are secured to them by means of screws or nails. The treatment of jambs for doors and other openings is illustrated in Fig. 71. In (a) is shown a sheet-metal I stud *a* composed of two channels fastened

together. At *b* is an I stud, at *c, c* two coverings of metal lath, and at *d, d* the plastering on each side of the partition. The wooden buck is shown at *e*, and plaster grounds at *f*. In (b) channel studs are shown at *a* and *a*. The method of constructing partitions with channel studs and with rolled-steel studs is the same as with the I studs.

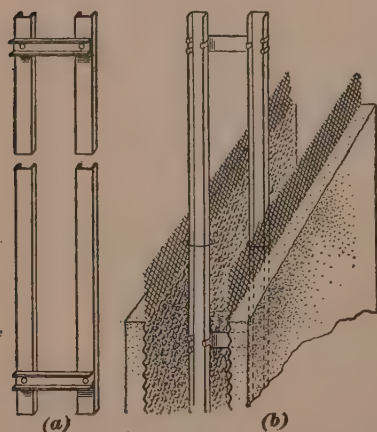


FIG. 72

Studs of the sections shown in Fig. 71, as well as the rolled-steel sections, can be depended upon to support a certain amount of load in proportion to their height and the sizes of the studs. Studding for

hollow partitions is sometimes built up of light steel sections where the partition is required to be thick. A rolled-steel studding of this kind is shown in Fig. 72 (a). A similar form of studding made of sheet metal is shown in Fig. 72 (b).

FURRING

115. Furring is a framework of steel or wood designed to support lath and plastering; the term is also applied to the materials used for the purpose. Furring is usually attached to the structural parts of a building, such as walls, floors, partitions, etc., and does not, as a rule, add to the strength of the building. Furring is applied to masonry walls to hold the lathing and plastering away from the surface of the wall so as to form an air space to prevent the passage of moisture. Furring of metal or wood is also used in making false constructions of plaster, such as cornices, coves, domes, beams, and other architectural or constructional forms. In the following discussion, metal furring only will be considered.

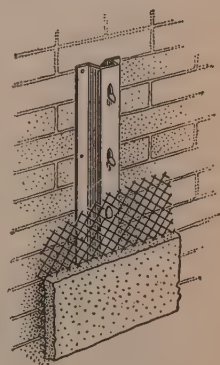


FIG. 73

116. Furring Walls.—Walls are furred to form an air space between the face of a masonry wall and the plastering to prevent the passage of moisture, which sometimes penetrates masonry walls. A space of an inch or so is sufficient. Metal furring may consist of separate pieces of metal which are attached to the surface of the wall and to which the metal lath is attached, or may be formed in the sheet of metal lath. The separate furring may be of the same forms as the metal studding that has been described, namely channels, angles, etc., or of forms especially designed for the purpose. In Fig. 73 is shown a sheet-steel furring which is nailed to the wall through the holes shown on the sides and which holds the metal lath by means of prongs.

In Fig. 74 is shown a rolled-steel channel used as a furring. This channel is secured to the wall by means of large staples that are driven into the joints of the brickwork. The flange of the channel has holes punched in it through which wires are placed to secure the lath.

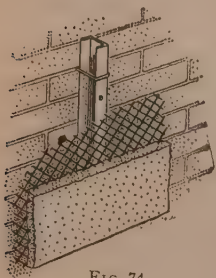


FIG. 74

A combination furring and lath is shown in Fig. 75 in which the **V** stiffeners *a* act as furring strips and hold the lath *b* away from the wall. The metal lath and the stiffeners are stamped out of the sheet at the same time.

117. Furring Flat Ceilings.—Flat metal-lath ceilings are made of either of two forms of construction, the one requiring a framework to which the lath is applied and the other being formed of a lath

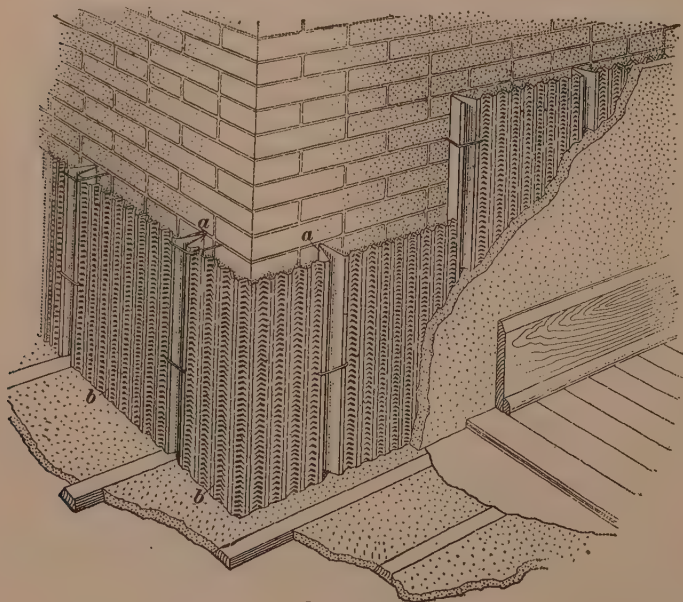


FIG. 75

that is reinforced and is sufficiently strong to span between the structural beams of the ceiling or between suspended beams.

The forms of lath used for these two classes are similar to those used for partitions and furred walls.

118. In Fig. 76 is shown a simple form of construction that is typical for all metal-lath suspended ceilings that have a framework. The suspension rods *a* have one end formed to fit the lower flange of the steel beam, and clips *b* are attached to these rods to form secure connections with the beams. The lower ends of the rods are bolted to angle irons *c*, and channel irons *d* are secured to these angles by means of wire clips *e* specially made for this purpose. In this illustration, expanded-

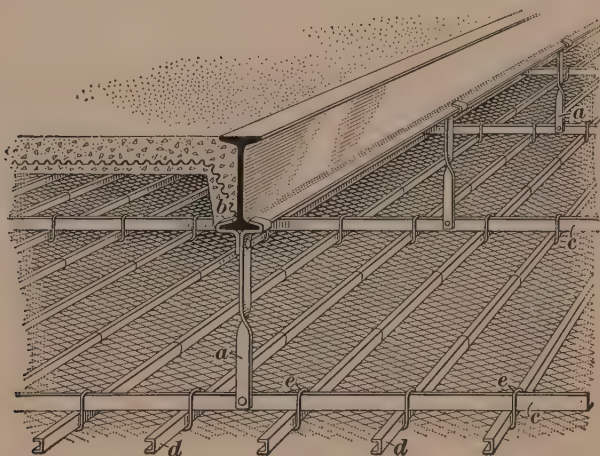


FIG. 76

metal lath is shown and this is tied to the channels by means of wires. The channels *d* are 1 inch in size and are spaced 12 inches on centers. The angles *c* are $1\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. $\times$ $\frac{3}{16}$ in. and the suspension rods *a* are 1 in. $\times$ $\frac{3}{16}$ in. The angle irons are usually spaced about 4 feet apart.

119. Metal lath having ribs or other forms of reinforcement is attached to the bottoms of the beams, or suspended below the beams, and either the channels or angles, or both, may be omitted.

Where this form of lath is placed directly under the lower flange of the beam, any form of fastening may be used that

will have the required strength and make the connection rigid. As a rule, each manufacturer produces a special form of clip for attaching his style of lath to the beams. For a suspended ceiling, however, suspension rods similar to those previously described will be required, also angles of similar size and spacing, the intermediate channels, however, being replaced by the

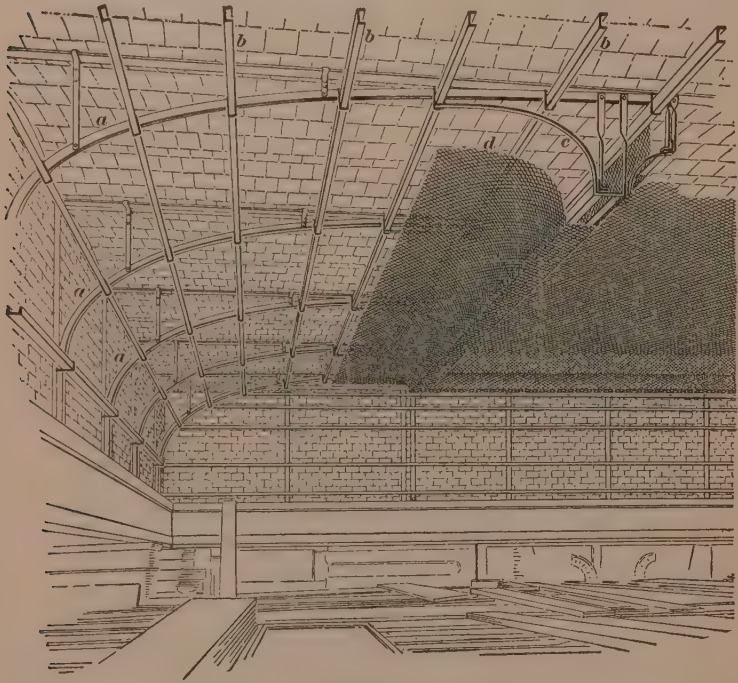


FIG. 77

ribs in the lath. When applying the lath to the angles, each rib of the lath should be strongly fastened to the angles.

120. Furring Curved Ceilings.—Metal-lath ceilings are sometimes formed with curved surfaces. The principles involved in the construction of all curved ceilings are practically the same, consequently only one illustration will be given.

In Fig. 77 is shown a ceiling having a large curved surface at the intersection with the side walls, which is called a cove.

Between this cove and the flat ceiling is a suspended frame and metal-lath covering that is to receive an ornamental plaster beam.

The curved bars *a* are usually formed of steel angles and their size will depend upon the size of the curved surface they form and the load of plaster they are required to carry. These angles are securely fastened to the wall and ceiling construction. To these angles are fastened the regular channels *b*, which are usually 1 inch in size. In this illustration, at *c* is shown a bracket formed to receive the metal lath for a sec-

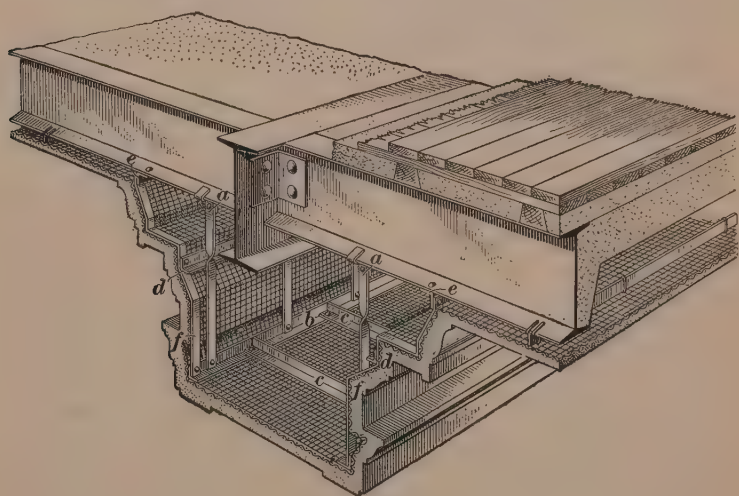


FIG. 78

ondary plaster cove; and at *d* is shown the metal-lath covering over the framing of the cove which is approximately of the form and size required for the finished work.

121. Furring for Cornices and Beams.—Metal furring and metal lath are used in constructing large-sized cornices and false beams in fireproof buildings. In furring these features, the frame is made to conform as nearly as possible to the profile of the feature so that the plastering will not be unnecessarily thick.

The frame is made of plain flat bars, angles, or channels that are securely bolted together and secured to the wall or to steel

beams. Metal lath should be plain expanded metal or metal fabric of light weight so that it may be easily bent around the frame into the required shape.

122. Fig. 78 shows a false beam with a cornice on each side. The furring and metal lath are also illustrated. The hangers *a* are similar to those shown for the hung ceiling in Fig. 76. These hangers are connected to horizontal angle bars, one of which is shown at *b*, Fig. 78. This angle and a similar one on the other side of the beam are connected together and braced by means of crosspieces *c*. Other angle bars are shown at *d* and *e*. At *f*, *f* are shown flat bars that are formed to an approximate outline of the cornice and which are connected with the horizontal angles to form a framework that is strong and rigid. It will be noted that the angle bars at *e* are connected directly to the structural beam of the ceiling.

PLASTERING

123. Purpose of Plastering.—The object of plastering, from the standpoint of fireproofing, is to protect metal from the action of fire. In the case of protecting columns, beams, partitions, etc. from fire, the furring and lath are attached to these various members and the lath is embedded in a good coating of plaster. The value of this coating depends upon the quality of the plastering. Cement plaster made of 1 part Portland cement, $\frac{1}{10}$ of a part of hydrated lime, and $2\frac{1}{2}$ parts of sand has a great fire-resisting value and affords the best protection that can be obtained by using plaster. Patent plasters, of which the base is gypsum, have not the fireproofing value of cement plaster. They are, however, good fire retardants and afford considerable protection to metal lath, furring, and steel studding enclosed by them.

124. Method of Applying Plaster.—The method of applying plaster to metal lath is described in another Section. The construction of the solid partition, however, is somewhat different. In this construction, the plaster is first applied to

one side of the metal lath and when this plaster has set the other side is plastered. This process is repeated until the full thickness of the partition has been obtained.

FIREPROOFING WITH PLASTER BLOCKS

125. Plaster Blocks.—Plaster blocks, that is, blocks made of plaster of Paris mixed with various substances, such as cinders, coconut fiber, asbestos, or wood chips, are sometimes used both for column coverings and for partitions. Notwithstanding their value as heat insulators, they are softened by the heat, and easily washed away by a stream of water from a hose, and the softening and washing will penetrate deeper than with other materials.

In small buildings or buildings in which the highest degree of fireproofing is not essential, plaster blocks can be used advantageously for partitions and on account of their cheapness prove very satisfactory for this purpose. Plaster blocks can be cut with a saw and possess considerable holding power for nails. They are light in weight and when plastered on both sides will offer sufficient resistance to heat and flame to warrant their use in ordinary buildings.

MISCELLANEOUS FIREPROOFING MATERIALS

126. In the fireproofing of buildings, the aim is not only to prevent a collapse of the building through failure of some of the steel supporting members, but to confine a fire that might originate in one part so it will not spread to other parts of the building. The fireproofing should also be designed to prevent the fire from passing through door or window openings to adjoining buildings and from entering the building from adjacent burning buildings. This has led to the manufacture of new materials and the using of old materials in such a way that they will fireproof all openings. Some of these new materials will next be described.

127. Fireproof Wood.—Among the fireproof materials used for trim in buildings and approved by most of the building codes, is fireproof wood. This is ordinary lumber which by a special process has had the resin, oils, and other inflammable materials abstracted, leaving only the cellular tissue of the wood. It is then impregnated with chemicals and covered with a fireproof paint. Wood so treated will glow but not flame, and may be considered fireproof. Closely allied to fireproof wood protected by fireproof paint is a process of treating wood to give it the appearance of metal. This consists of electrically depositing a layer of copper on the exposed surfaces of the wood, which is then said to be *copperized*.

128. Metal-Covered Wooden Trim.—There are several makes of wooden interior trim on the market, all of which are made fireproof by covering the wood with sheet metal of some kind. Metal-covered trim can be had that is covered with iron, copper, bronze, or any other metal or alloy. Some of the finishes are crude in appearance, while others are very attractive.

Under the trade name of *Kalamein Iron*, trim may be had that is covered with sheet steel, the surface of which has been specially treated with a coating of tin and lead in much the same manner that galvanizing is applied to iron or steel.

129. Metal-Covered Window Frames and Sashes. Metal-covered window frames and sashes are likewise made and fill an important place in fireproof construction. On account of the sash and frame being exposed to the elements it is desirable to cover them with bronze or some other non-corrosive metal that will not deteriorate.

130. Hollow Metal Doors and Trim.—In hollow metal doors and trim is to be found a high type, artistically and structurally, of fireproofing. Unlike the metal-covered doors and trim, hollow metal doors have no core of wood or other material with the exception of the material placed between the two faces of the doors to back up the sheet metal and deaden the sound.

Hollow metal doors, trim, sashes, windows, etc., are enameled and rubbed to a dull gloss and used in the finest of buildings.

131. Cement Trim.—In many fireproof buildings the floors and base are made of cement or some similar plastic material and the door and window trim is made of Keene cement and finished in imitation of woodwork, thus providing a finish that is cheaper than metal and which is also fireproof.

132. Wire Glass.—The manufacture of glass with a wire mesh embedded therein makes it possible to secure protection from fire through window openings without disfiguring the building by the use of fireproof shutters. This form of glass is made by rolling the wire into the plastic glass at a temperature which causes it to adhere to the wire. Should the glass become cracked or broken during the course of a fire, the wire mesh will hold it in place and prevent the spread of the flames through it.

133. Steel Shutters.—Another method of guarding windows and also doors is by the use of shutters, of which there are two types, the steel rolling shutter and the tin-covered shutter. The steel rolling window shutters are illustrated in Fig. 79 at *a*, and a door shutter at *b*. These shutters are constructed so that they can be raised or lowered by hand or so that they will act automatically in case of fire. The automatic action is produced by the use of links or plugs of fusible metal, as described later for tin-clad doors, and springs. Such automatic shutters may be used on interior openings as well as on exterior ones. Thus, in closing openings to elevators and stair halls these shutters are very useful in preventing the spread of fire. It is especially necessary to protect openings that are close to adjacent buildings that are dangerously inflammable.

134. Tin-Covered Shutters.—The tin-covered shutters are wooden shutters built up of two or three layers of $\frac{3}{8}$ -inch boards, covered with sheets of tin that are put together with nailed lock joints and without the use of solder. The wood is protected from burning by the tin, and the stiffness of the wood keeps the shutters in shape under the action of a severe fire.

135. Of the tin-covered and the steel shutters, the tin-covered wooden shutters are the more effective. Under the action of the heat the steel shutters will warp and transmit

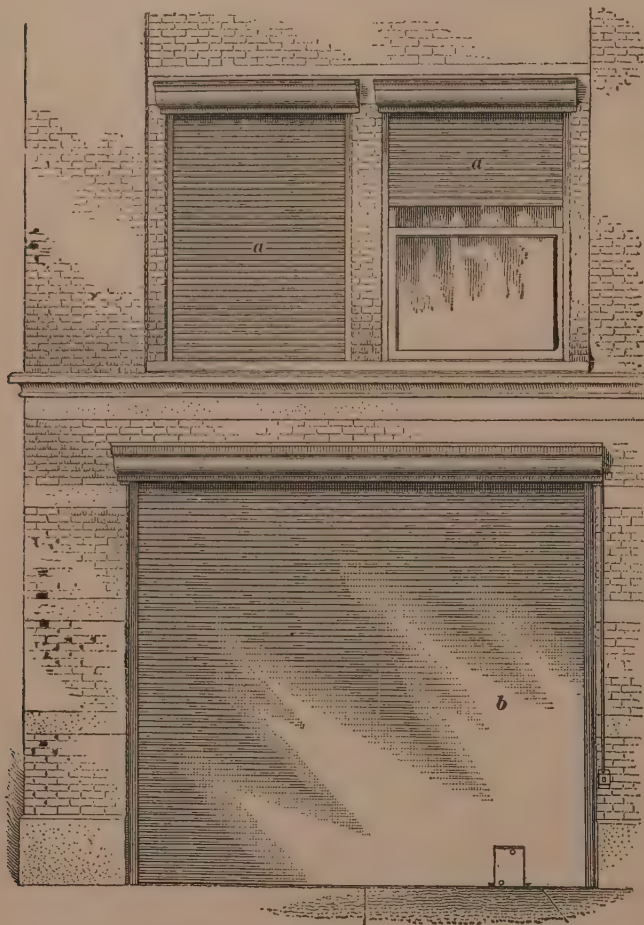


FIG. 79

heat very rapidly. Tin-covered wooden shutters, on the other hand, transmit heat very poorly, warp but little, and are the best protection against outside fire, so long as they are closed. The great weakness of shutters lies in the fact that they may

be open when a fire is raging and consequently afford no protection whatsoever.

136. Tin-Clad Doors.—Tin-clad doors are used in closing openings in masonry walls between various sections of a large building. Usually they are made to act automatically, that is, they are built so that in case of a fire reaching the opening a fusible link or plug of metal will be melted and the door will

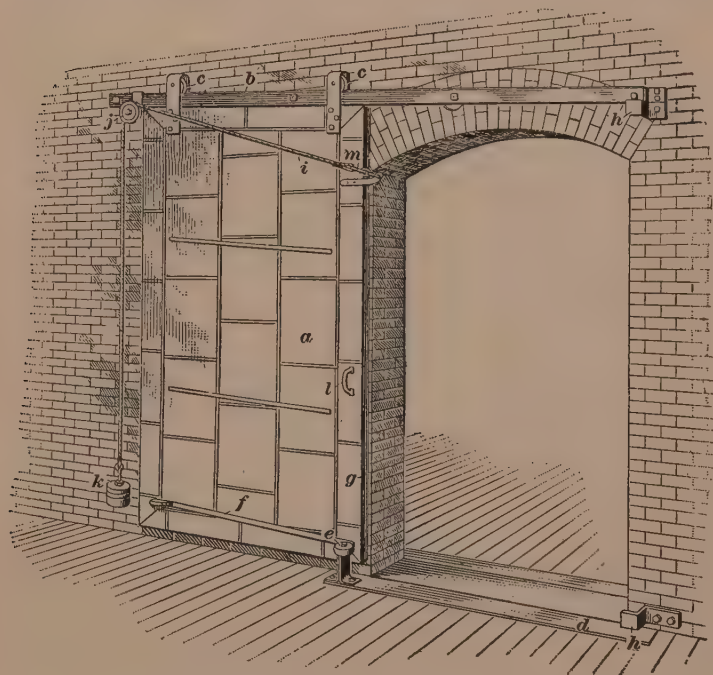


FIG. 80

close automatically. An automatic tin-clad door is shown in Fig. 80. The door itself is shown at *a*. This door shows the tin covering with the locked joints between the tin plates. The door is hung on the inclined track *b*. This track is a flat bar fastened to the wall by bolts that extend entirely through the wall. Between the wall and the bar are washers that keep the track away from the wall so that the hangers *c* can run freely along the track. These hangers are bolted to the door, the bolts

extending through the door. The track being inclined, the door will naturally close and stay closed if it is not held open by the devices shown. When open, the door is in a higher position, due to the slope of the track. When it is closed, however, the bottom of the door touches the iron sill *d*, which must extend beyond the face and edges of the door and must be secured firmly to the brick walls. In case of the floor burning away, this sill must remain in place. The bottom of the door is kept from swinging away from the wall by the roller *e*, which is also bolted to the wall or sill. Secured to the door is a strip of iron *f* upon which this roller presses. When the door is closed, the edge *g* enters the bumpers *h*, which hold it close against the wall, while the roller similarly holds the other edge. A sash cord *i* extends around the pulley *j* and is attached to the weight *k*. This holds the door open. The door is closed by simply pulling it to by means of the handle *l*. A piece of metal that will melt at a very low temperature, called a fusible link, is shown at *m*. If the door is left open and a fire occurs on one side of the wall, when the flame, or even intense heat, reaches this link, it will melt. This will release the cord *i* and the weight *k* will drop. The door will then of its own weight roll down the track and close. A door such as the one just described will resist a tremendous fire. These doors should always bear the Underwriters' Laboratories label indicating that they are approved by the National Board of Fire Underwriters and when possible should always be placed on both sides of a wall.

There are many different patterns and makes of these doors and appliances. There are also various types of doors that can be used, such as double sliding doors, swinging doors, and doors that slide upwards. These various types are described in booklets issued by the National Board of Fire Underwriters. They are also made and sold by various concerns that make them in accordance with the rules of the National Board.

137. Protecting Openings to Stairways and Elevator Shafts.—In the fireproofing of buildings it is of special importance to protect all approaches to elevator shafts and

stair wells, so that fire cannot reach them. This is done by enclosing the shafts and wells in fireproof walls and by having the openings protected by fireproof doors. During a fire, the stairways and elevator shafts, if left exposed, will act as flues, giving draft to the fire, shutting off all escape from the upper floors, and allowing the flames to spread to all parts of the building. Whenever there are window openings, either to stair wells or elevator shafts, they should have wire glass set in fireproof frames to protect them from fire from without.

FIRE-EXTINGUISHING METHODS

138. Portable Fire Extinguishers.—Fire extinguishers, as they are generally called, are portable devices that contain chemicals of such a character that when these chemicals are discharged and spread over a flame they will form a gas that shuts out the air and thus extinguishes the fire.

139. Buildings that contain valuable materials or goods are protected against loss by fire by automatic sprinkler systems or by standpipe systems. These equipments become a permanent part of the building, and a brief description of their operation will be given.

140. Automatic Sprinkler Systems.—As the name implies, automatic sprinkler systems are automatic in their operation and consist of outlets, in or near the ceiling, which are placed at regular intervals and equipped with what are known as *sprinkler heads*. The heads are provided with fusible links so designed that they will melt at a low temperature such as may be produced by a fire at its beginning. The melting of the fuses opens the heads, and water is sprayed over a given area, the heads being so located that the entire floor of the building is thus provided with this protection. The water is supplied either from an open tank, which is placed on top of the building to obtain a suitable pressure by gravity, or from a closed steel tank which has had air pumped into it to secure the necessary pressure of water. The tanks are made with a

capacity only sufficient to supply water for a limited period of time pending the arrival of the fire engines.

141. Standpipe System.—Another form of fire protection is the *standpipe system*. This consists of a vertical pipe, usually located in a stair well, which extends from the basement to the top story of the building. The bottom of this pipe is connected with the city water main in the street and at each story is a branch pipe, a controlling valve, and a hose, the latter being placed on a reel of some form. In case of fire the hose is removed from the reel, one end of the hose being connected with the standpipe, the valve is opened, and water is supplied directly from the city water main to extinguish the fire. In high buildings, the city water pressure is not always sufficient to supply water to the upper stories, and auxiliary pumps or tanks are often required to make the standpipe system operative for these stories.

AREAS, VAULTS, AND RETAINING WALLS

AREAS

INTRODUCTION

1. Definition.—An area is an enclosed sunken space that is formed outside of the foundation wall of a building for the purpose of admitting light and air into a basement or cellar, or to provide access to a basement or cellar entrance.

2. Types of Areas.—Areas may be classified, according to their purpose, into three types. One type is designed to allow of *lighting* a basement or cellar of a building; examples of this type are shown in Figs. 4 and 6. Another type is designed to be used as a *means of access* to a basement or cellar, as shown in Figs. 7 and 16. The third type is designed to be used as a *means of access* to a basement and also to allow of *lighting* the basement; this type is shown in Figs. 10 and 14.

3. Parts.—Areas consist of walls and of the following parts; namely, steps, floors, drains, balustrades, railings, gratings, and covers.

The **walls** which enclose the sunken space and keep the soil surrounding the area in place, are called *area walls*. These walls should be strong enough to resist the pressure against the wall, known as *lateral pressure*, due to the weight of the soil adjacent to the area. The principles that govern the design of these walls are the same as those used in the designing of

retaining walls, a subject which is discussed later on in this Section.

Area steps are installed to provide a means of access between the grade level of the soil or the sidewalk adjoining the area and the area floor.

A **floor** is installed in the area to protect the foundations of the area walls, by keeping the foundation walls of the building dry, and also to form a pavement in the area.

Drains are installed in areas that are paved, to carry away the water from the area floor.

Balustrades, railings, gratings, and covers are installed to prevent persons from falling into the area and being injured.

In the area illustrated in Fig. 14, the enclosing walls are shown at *a*, *a*, the steps between grade level and the area floor are shown at *b*, the area floor at *c*, and the floor drain at *d*. In this illustration, a railing, shown at *e*, is used to prevent persons from falling into the area, while in Fig. 19 (*a*) is shown a grating *e* that is intended for this purpose.

4. Building Laws.—The building laws, or codes, of nearly all cities, require areas that are located in front of buildings and which extend into sidewalk space, to be covered or enclosed in such a manner as will insure the safety of pedestrians. These codes often also place restrictions on the size and the location of the area, and should be consulted when areas are designed to be constructed in such cities.

AREA WALLS

5. Materials.—Area walls may be built of terra-cotta tile, brick, stone, concrete in the form of blocks, plain concrete which has been poured, or reinforced concrete; that is, concrete into which steel rods or steel mesh have been embedded.

The choice of material depends upon what is available in the locality where the work is to be done, its cost relative to other materials, and sometimes upon what kind of material is used in the foundation walls of the building.

6. Excavations.—Excavations for areas should be made sufficiently large and deep to receive the walls and footings and also to allow ample space outside of the walls for the performing of other operations that may be necessary, such as bracing of the soil, pointing of the wall, waterproofing, or building of forms for concrete if concrete construction is contemplated. Special care should be taken, in making the excavations, not to disturb the adjoining soil or cause it to fall into the excavated space while the area walls are being built.

As a general rule, all excavations for walls that are to be erected in localities that are subject to freezing weather should be carried down to a level that is below the frost line.

7. Bracing of the Soil.—If the soil which surrounds the area is likely to break or fall into the excavated space before the area wall is built, or if the excavation is being formed in sand or gravel, it will be necessary to erect braces or supports to hold this soil or gravel in place temporarily. If the wall of the building has been previously erected, the bracing may be of the form shown in Fig. 1. To construct this bracing the posts *a* are first driven into the soil and the upper ends are braced against the building by means of the timbers *b*, these timbers being nailed to the blocks *c*, secured to the wall of the building. The posts should be located a sufficient distance outside of the area

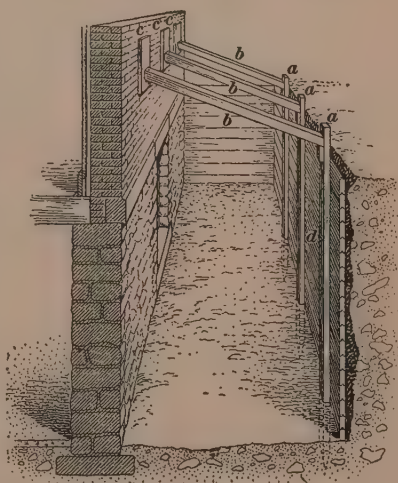


FIG. 1

wall to permit of its construction, and the timbers *b* should also be placed high enough so that they will clear the top of the wall when it is built. The boarding *d* should be of matched

material with the tongue driven into the groove to stiffen the boarding between the posts.

8. If the wall of the building has not been erected, the bracing of the soil may be accomplished as shown in Fig. 2. In this form of construction the posts *a* are braced by means of the timbers *b* and *c*, and these timbers are securely nailed to the stakes *d*, and the posts *a*. If this construction is used it will also be necessary to locate the posts a sufficient distance outside of the wall to permit of the building of the wall and it will be necessary to build the wall around the timbers *b* and *c*. After the mortar in the wall is thoroughly set, these braces are removed and the openings filled with masonry.

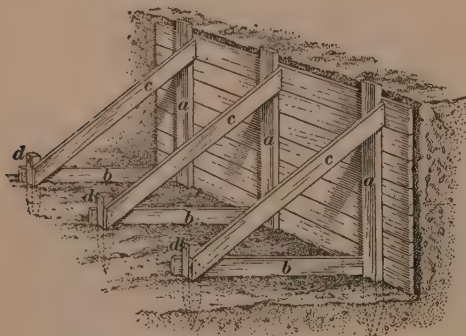
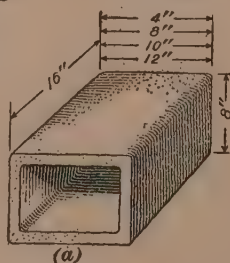
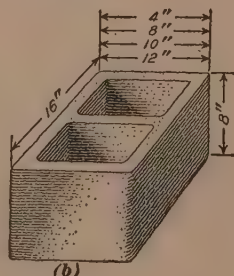


FIG. 2



(a)



(b)

FIG. 3

9. **Walls of Terra-Cotta Tile.**—There are two kinds of tile that are used for building area walls, the *hollow building tile* and the *conduit tile*. Both of these kinds are vitrified and salt-glazed and therefore are impervious to water.

Two forms of hollow building tile are shown in Fig. 3. In (a) is shown the form and the sizes in which the wall blocks are made, and in (b) is shown the form of tiles used for the corners of the wall, together with their sizes.

In Fig. 4 is shown an area having walls constructed of *hollow building tile*. The foundation walls of the building are also

constructed of the same material and the blocks shown at *a* are left projecting from the wall to form a tie with the area walls, which are built after the foundation wall is completed. In the top row of tile, the standard corner tile is not used. Instead, a regular wall block is used. The open end of the tile in the top course has been filled with broken pieces of tile bedded in cement mortar and coated to make a neat finish, as shown at *b*.

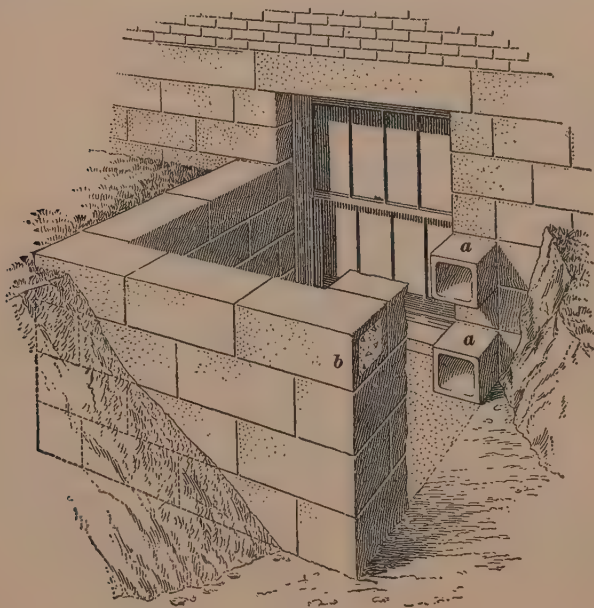


FIG. 4

Forms and sizes of *conduit tile* are illustrated in Fig. 5. This type of tile is made for the purpose of carrying underground telephone, telegraph, or other electrical wires. For building purposes, however, tile having slight defects which make them undesirable for conduit purposes, and classed as *seconds*, are often used and are perfectly satisfactory for walls. In (*a*) is shown a tile containing four openings, called cells. This tile is 9 in. $\times$ 9 in. in cross-section. In (*b*) is shown a tile 9 in. $\times$ 13 in. in size containing six cells. The lengths of these tiles vary from 18 inches to 36 inches.

10. Walls of Brick.—Brick walls of areas should be constructed in the same manner as brick foundation walls. The brick should be hard, dense, and thoroughly bonded together. All the joints and crevices should be filled with cement mortar so as to make a strong wall, and the joints on the faces of the wall should be carefully pointed to keep out water.

Brick area walls are sometimes built in the semicircular form shown in Fig. 6. This form of area is used for small windows that do not extend very far below the grade level, and the walls are usually made of a thickness that is equal to the length of one brick. If, however, the diameter of the semicircle exceeds 3 feet, the thickness of the wall should be increased.

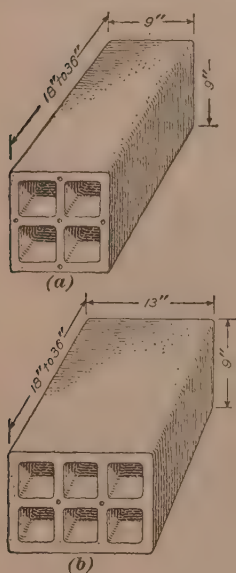


FIG. 5

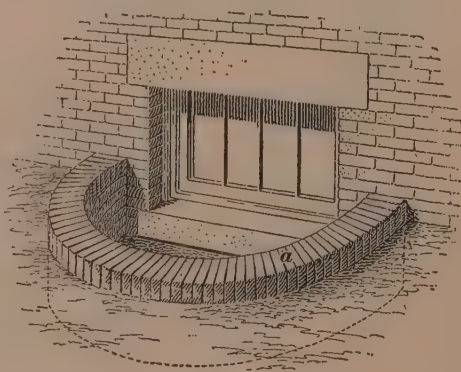


FIG. 6

11. The coping is a feature designed to prevent water entering the top of the wall. In Fig. 6, it is formed of regular shaped brick as shown at *a*. The bricks are laid on their long narrow edges and the joints are entirely filled with a mortar made of equal parts of Portland cement and sand to render it impervious to water. The cement-mortar joints on the top of this coping should be troweled flush with the brick so that water will not stand on the surface.

An example of an area which is used as a means of access to a basement, and which has brick walls, is shown in Fig. 7,

The walls *a* extend above the grade level and take the place of a railing. The tops of these walls are also protected by means of brick copings *b*, special shaped brick *c* being used to form the corners of the coping. At *d* is shown one of the stone steps leading down into the area.

The walls of the area shown in Fig. 8 are rather high and must be made strong to resist the lateral pressure produced by

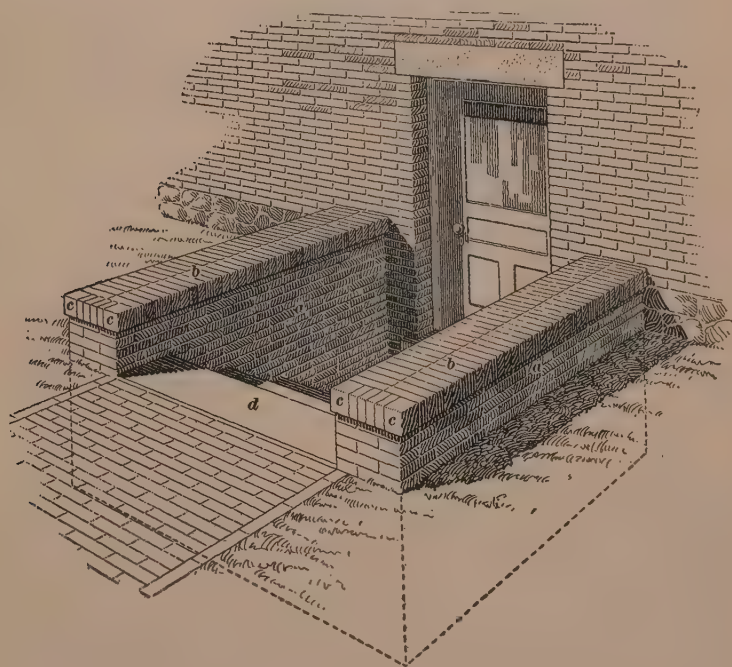


FIG. 7

the adjoining soil. They are assisted in doing this by the brick arches *a*, which are built at suitable intervals. The coping for the walls is formed of thin flat stones *b*, and a coping of similar character is used for the walls which form the braces, as shown at *c*. These coping stones should be long, to insure few joints through which water can enter the wall, and they should be cut so that these joints will occur between the posts of the rail-

ing, as at *d*, for the stones are liable to be broken by the cutting of holes for these posts if the holes are near the ends of the slabs.

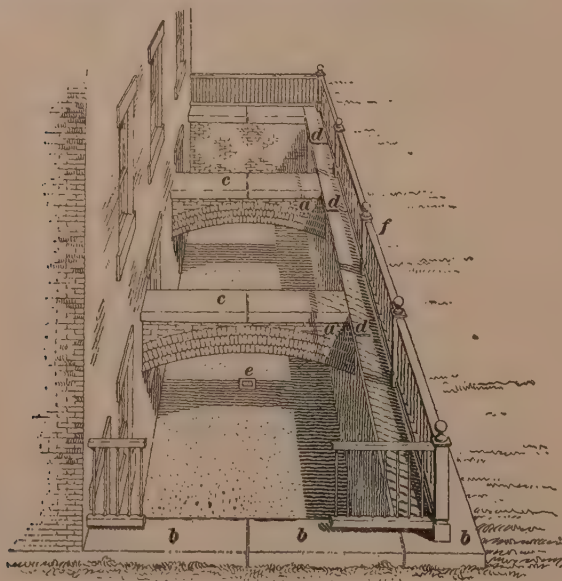


FIG. 8

All copings should be sufficiently wide to project from 1 inch to 2 inches beyond the faces of the wall, and the under side of this projection should be cut in such a manner as will cause

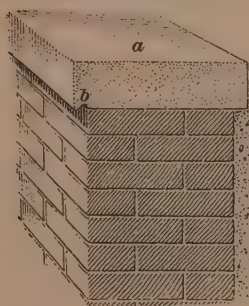


FIG. 9

the water from the coping to drip free from the wall. Coping stones cut in this manner are said to be cut with a *drip*. In Fig. 9 a coping stone is shown at *a* and the drip is shown at *b*. No drip is cut on the outer edge of this coping, as the soil is filled against the wall and the drip is not required.

12. The area shown in Fig. 10 has brick walls *a*, reinforced by means of brick buttresses or pilasters *b*, to assist the wall in resisting the pressure from the

adjoining soil. These walls extend above the grade to act as a railing, and have stone copings as shown at *c*. The coping is of the design shown in Fig. 11 at *a*. The top is formed with a slope to each side to drain away the water, and both edges are cut with a drip, as shown at *b*.

13. A coping of this same general shape may be made by pouring concrete into wood forms of the shape shown in Fig. 12 (*a*) are used, similar to stone slabs, or it may be formed on the wall in one section.

To cast it in sections, wood forms of the shape shown in Fig. 12 (*a*) are used, and after the concrete has become hard the slab is removed from the form and placed on the wall as shown at *a* in view (*b*). If the coping is cast directly on the wall, a form is erected as shown in Fig. 13 and into it the concrete is poured. This form requires wooden posts *a* to which the boards *b* are secured. The posts outside of the wall may be driven into the soil to secure them in place, but the posts on the inside of the area wall will require braces. At *c* is shown a brace which is secured both to the post and the form, and the

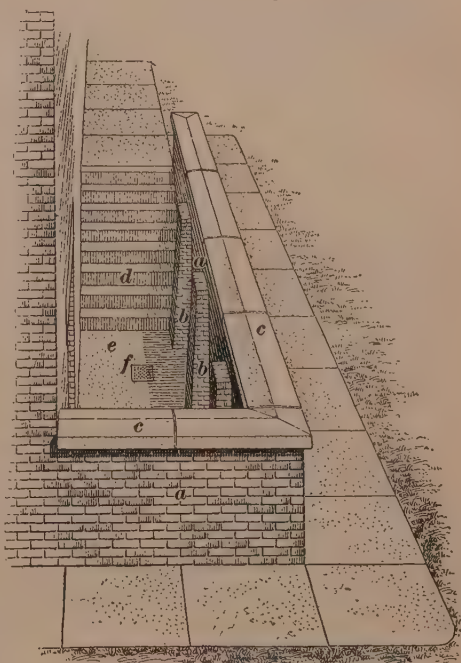


FIG. 10

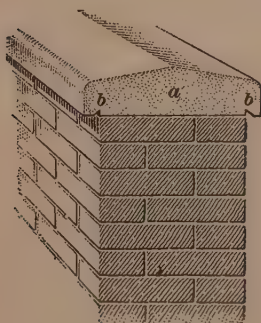


FIG. 11

opposite end of this brace is placed against the foundation wall of the building.

At *d* is shown concrete which has been placed in the form,

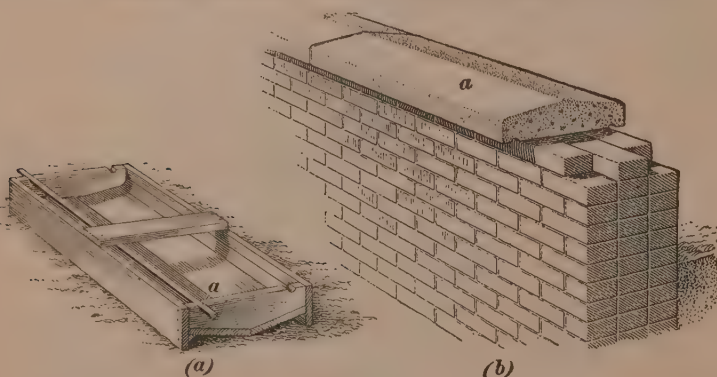


FIG. 12

and at *e* is a template which has the lower edge formed to the shape desired for the top of the coping. This template also has running edges and shoulders as shown at *f*, and by operating it back and forth the surface of the concrete is formed into the

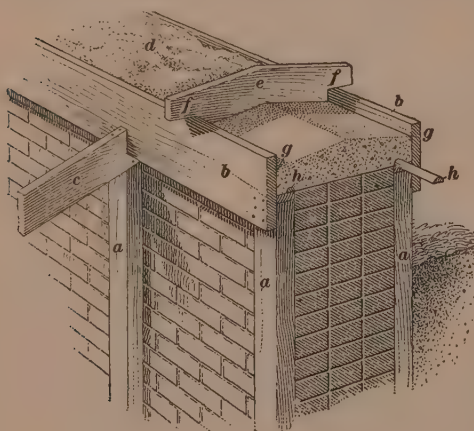


FIG. 13

shape desired. After the concrete has hardened sufficiently to permit of the removal of the forms, the edges *g* of the coping should be slightly rounded by rubbing with a piece of sand-stone and some water.

All concrete copings should have drips similar to those shown for stone copings. These drips

may be made in the concrete by placing half-round wooden moldings in the forms, as shown in Fig. 12 (*a*) at *a*, and in Fig. 13 at *h*.

Wooden forms for concrete copings should also be designed to provide suitable openings for iron posts of railings or balustrades, where such members are contemplated.

As soon as the wooden forms are removed the concrete copings should be examined and carefully repaired with cement-and-sand mortar. Concrete coping slabs should be set in cement mortar and the joints between the slabs should be filled and pointed in the same manner as the joints between stone slabs.

Copings, or coverings, are occasionally made of rich cement mortar not less than 1 inch thick and troweled on so as to form a smooth sloping surface. This treatment is a cheap one, but the work will not last a great length of time.

14. Walls of Stone.—Stone for area walls should be of a dense and non-porous variety and

laid only in cement mortar. Walls of this character are usually made in rubble work; an example of such a wall is shown in Fig. 14 at *a*. This wall has a projecting footing, as shown at *f*, which is formed of concrete, but this may be of large stone if so desired. These footings are usually made from 6 inches to

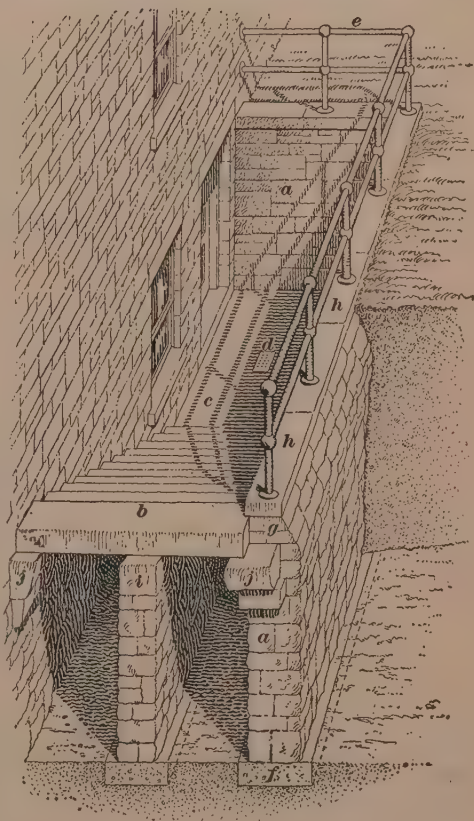


FIG. 14

8 inches thick and project about 6 inches beyond each face of the wall. The top of this wall is tapered as shown at *g*, to permit of the use of a narrow coping *h*, as a coping made wide enough to cover the entire thickness of the wall would be unnecessarily expensive. The joints in the masonry of this sloping, or tapered, surface should be carefully pointed to prevent water entering the wall.

Areas of this type that are 6 feet or more in width should have an additional wall as shown at *i*, known as a dwarf wall,

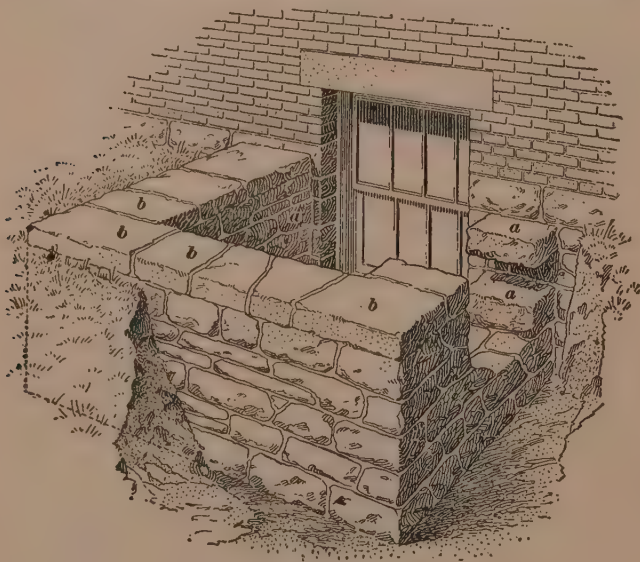


FIG. 15

to support the middle of the stone steps. The ends of these steps may rest on stones that project from the foundation and area walls as shown at *j*, or they may extend into the walls for a bearing. If of this latter construction, the steps must be set while the walls are being erected.

The area shown in Fig. 15 also has walls of rubble stonework, and although the area is small the walls are usually made 18 inches thick, as it is not economical to build them of less thickness in this material. At *a* are stones that project from the foundation wall of the building to furnish a tie, or bond, for

the walls of the area. The coping of these area walls is formed of roughly dressed stone, as shown at *b*.

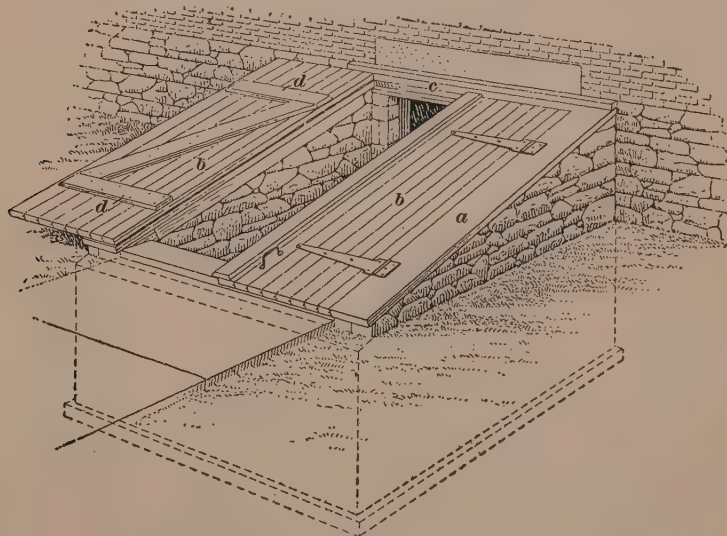


FIG. 16

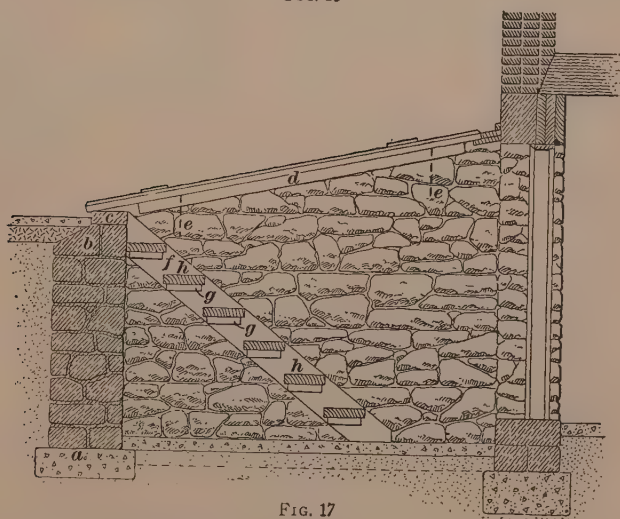


FIG. 17

15. The area shown in Figs. 16 and 17 is one that is frequently used as an entrance to the cellar of a private house.

The walls are usually built of brick or rubble stone and sometimes have a footing, as shown in Fig. 17 at *a*. The top of the wall is usually tapered as at *b*, and a single slab of stone *c* is used to form a coping and also to serve as the top step of the stairs. The side walls of this area are carried up the full thickness, and a wooden plate *d* is placed on the top of the wall and secured in place by means of anchor bolts *e* set in the walls while they are being erected.

16. Stone slabs for area walls, as shown in Figs. 18 and 19, are used extensively in localities where sawed flagstones are

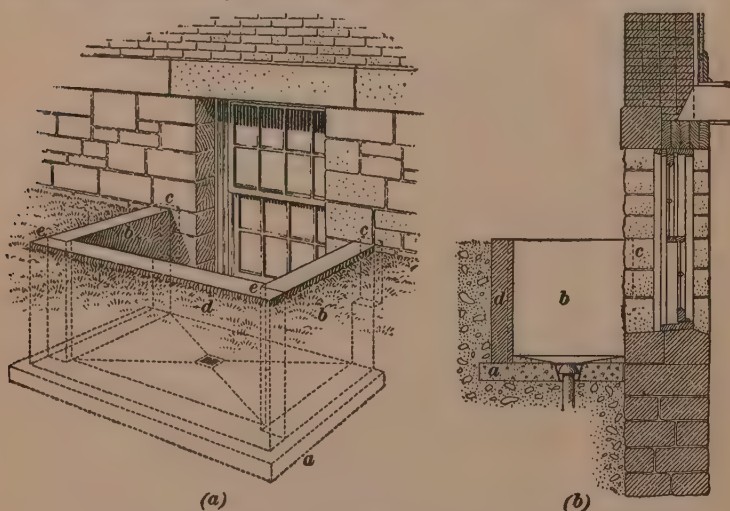


FIG. 18

easily obtained. These slabs are made 4 inches, 5 inches, or 6 inches thick, the thicker slabs being used for the larger-size areas. The edges of these slabs should be cut true and even to insure close-fitting joints and finished surfaces where they are exposed.

The type of construction shown in Fig. 18 is most commonly used. In this construction a part of one end of the slab *b* is set into a recess *c* made in the wall of the building, and the front slab *d* has each end recessed at *e* to receive the ends of the slabs *b*. After these slabs are assembled they will require to be braced until the soil is filled around the wall; when this is

done, the slabs will be retained in their proper position by the pressure from the soil.

Footings are usually required for these slabs, and when the area is to have a concrete floor this floor is often placed before the slabs are set and made sufficiently large to form a footing, as shown at *a*. Areas of the type shown in Fig. 19 are sometimes used where the soil is not sufficiently solid to carry the area walls. In this form of construction the area walls are carried entirely by the walls of the building and require to be erected at the same time as the building walls.

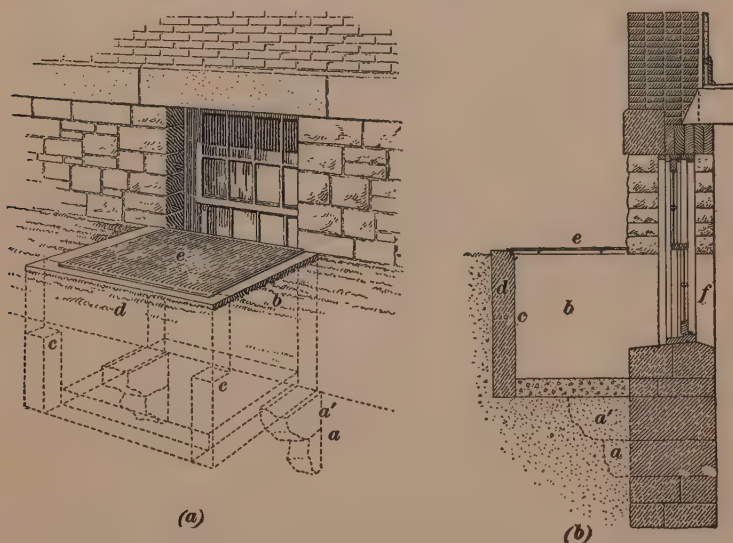


FIG. 19

The method of constructing this area is to project the stones from the foundation wall as shown at *a*, *a'*, and place the side slabs, one of which is shown at *b*, on these stones. These side slabs extend through the foundation wall, as at *f*, view (*b*), and form the jambs of this part of the window opening. The front ends of these slabs are cut with a shoulder as shown at *c* in view (*a*), the front slab *d* being formed with lugs on each end that will rest on these shoulders.

View (*b*) is a section through the area and basement window. In this construction the projecting stones *a*, *a'* are made

sufficiently wide to form a bearing for the floor of the area when it is placed.

17. Walls of Concrete Blocks.—Concrete blocks such as are shown in Fig. 20 are laid and bonded in the same manner as the terra-cotta hollow building tile which are shown in Fig. 5. The standard form of block is shown in Fig. 20 (a); a block that is used for the corners of the wall is shown in (b), and a form of block that is finished on the top, sides, and ends and designed to be used as a coping member for the corners of the walls, is shown in (c).

Walls formed of concrete blocks, when liable to be subjected to moisture, should be waterproofed. This may be done by adding a waterproofing compound to the concrete when it is mixed, or the blocks may be treated with a coating after they

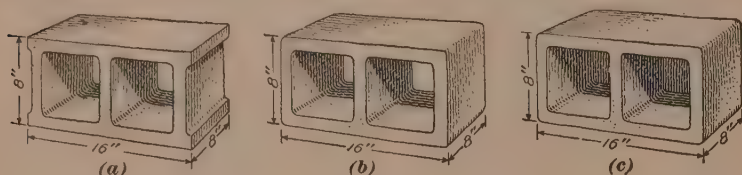


FIG. 20

are formed. Walls may be waterproofed after they are erected, if so desired, as described later under the head of Waterproofing.

18. Walls of Plain Concrete.—Walls of plain concrete require the erection of wooden forms into which the concrete is poured. When these walls are such that a footing is required, the footing, as shown in Fig. 21, at *a*, is usually installed first and the concrete allowed to harden, after which the forms are erected for the wall. In this method of construction provision should be made to bond the footing and the wall together to prevent the wall from slipping off the footing on account of the lateral pressure from the surrounding soil. This is often accomplished by placing pieces of stone in the concrete footing so that they will project above the surface, as shown at *b*. In this illustration are shown wooden forms and braces such as are frequently used in constructing poured concrete walls.

The posts *c* are set on the concrete footing *a*, and these posts are held in place and braced by means of the timbers *d* and *g*. The bracing members are nailed to the stakes *e*, and boards *f* are fastened to the posts as shown.

When the excavations are made in a soil that is sufficiently firm to retain its form and not fall into the excavated space, the excavations may be made the exact size of the outside lines of the wall and only the inside forms need be used, the concrete being poured between the soil and these forms. As the concrete is being poured, the part next to the forms should be

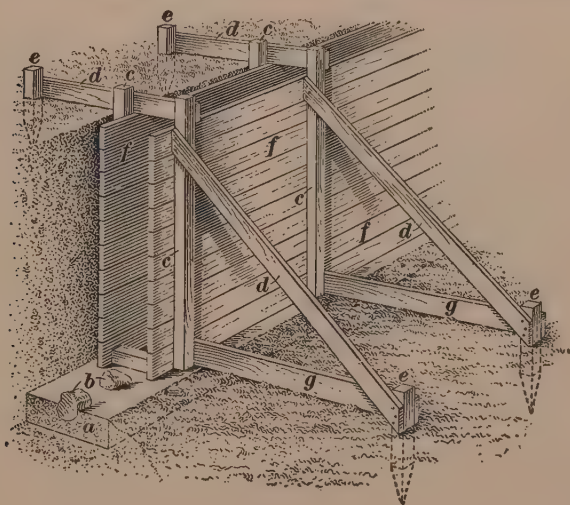


FIG. 21

thoroughly worked or puddled with a tool to insure the wooden forms being entirely covered with the fine parts of the concrete. This working of the concrete will tend to produce a smooth wall surface and one that is free from voids or exposed gravel, and will also tend to make a surface that is impervious to water.

When the foundation walls of the building are to be of concrete, the concrete area walls should be cast at the same time as the foundation walls to insure a bond between them. Small areas having concrete walls 6 inches thick, as shown in Fig. 22, are, however, often anchored, or tied, to the foundation walls by means of bars of steel, as shown at *a*. These bars are placed in

the concrete wall of the building while it is being cast and extend into both the area and foundation walls about 10 inches. In the area shown in this illustration, the floor concrete has been completed before the forms for the walls were erected, and the floor serves as a footing for the wall, as shown at *b*.

Large areas may be enclosed with walls formed of plain poured concrete if so desired. Such walls are usually made of the same thickness as walls of brickwork.

19. Walls of Reinforced Concrete.—Reinforced concrete is often used for area walls that are very high and which

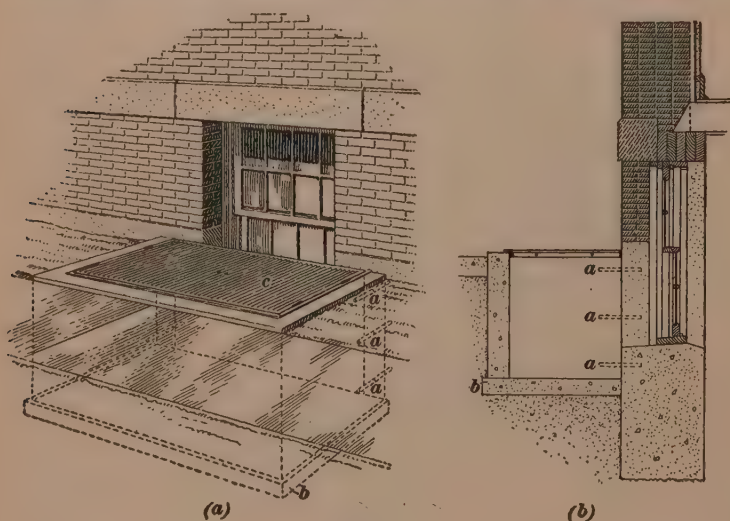


FIG. 22

consequently are required to be very strong in order to resist the great pressure due to a large amount of soil that adjoins the area. Reinforced walls, however, are not required to be so thick as plain concrete walls, consequently there is a considerable saving of concrete.

The methods used in erecting the wooden forms for these walls and the casting of the wall are similar to those for plain concrete work. The steel bars that reinforce the concrete are placed in the wooden forms, and securely fastened in the positions required before the concrete is poured. Walls of this

character are illustrated later on under the head of Retaining Walls.

20. Wall Facings.—Areas that are used principally by the public as a means of access to basements, frequently require that the walls be made especially attractive in appearance, consequently they are often faced with dressed stone, plain, glazed, or enameled brick or tile, or with marble. In selecting materials for this purpose, light colors are preferable if it is desired to light the basement by means of the area, as they will reflect the light instead of absorbing it.

The facing materials should not be installed until the rough work of the building has been completed, as otherwise it may be chipped or broken. Facings should be securely anchored to the walls, and joints should be thoroughly filled with mortar to prevent water from entering between the facing and the backing.

21. Waterproofing.—Area walls erected in a soil that does not permit of a good drainage of water often require to be waterproofed on the side adjoining the soil to protect the wall from being injured by the moisture. The materials most effective for this purpose are coal-tar pitch or a cement when properly applied. The subject of waterproofing is treated of elsewhere.

22. Back Filling.—After the area walls have been completed, and the forms removed, if forms have been required in the construction, soil should be filled into all open spaces around the walls and tamped down until it is compact and solid. The surface of this filling should be formed with a slope to drain water away from the walls.

AREA STEPS

23. Materials.—The materials that are most commonly used for steps in areas are wood, stone, brick, and concrete. Iron and steel are sometimes used in areas that adjoin city buildings where the space is very limited. Marble in the form of slabs is sometimes installed on a masonry foundation or on a framework of iron or steel.

24. Wooden Steps.—Wood is often used for steps in areas that are protected by a covering, but it is not so durable a material as stone, brick, or concrete. In Figs. 16 and 17 is shown a covered area which has wooden steps. These are constructed by placing supporting members, called carriages, against the side walls of the area, as shown in Fig. 17 at *f*, and securing these carriages to the wall by means of spikes driven into the mortar joints. Strips of wood *g*, called cleats, are then fastened to the carriages. The treads *h* are then fastened to these cleats and the carriages. The material generally used for both carriages and treads is 2-inch dressed plank.

25. Stone Steps.—Stone is a most satisfactory material for steps of areas and is generally used in the best class of work. Fine-grained blue sandstone is used extensively for area steps, although any stone may be used that is sufficiently hard and dense so that it will not absorb water and will withstand the wear. Stones that form steps should be provided with good bearings, be set in good beds of rich cement mortar, and have all joints filled and pointed to keep water from entering into the step foundations and causing them to deteriorate.

In many cases stone steps are made sufficiently long to allow the ends to extend into the walls at each side and thus secure a bearing on the walls, in which case they must be set while the walls are being erected. They may be of such length, however, that they will fit neatly between the area and foundation walls and rest on bearings formed by projecting some of the wall stones, as previously described and shown in Fig. 14 at *j*. On such bearings, the steps may be set during the construction of the adjoining walls or after they have been completed. It is better, however, to set them later, as they will not be subject to damage during the erection of the building.

Stone steps that are 6 feet or more in length should be provided with a bearing wall for the middle of the step, as shown in Fig. 14 at *i*.

Stone steps may be of solid slabs, as shown in Fig. 23 at *a*, or they may be constructed, as in Fig. 24, with separate slabs to form the treads *a* and the risers *b*.

The solid stone steps are more expensive than those formed of separate slabs, but they are very desirable as they are more

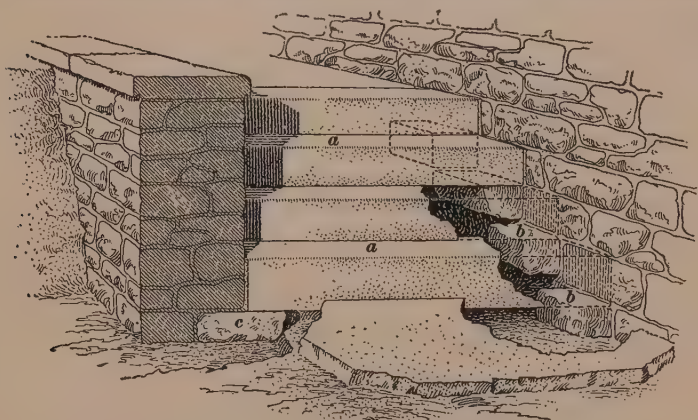


FIG. 23

durable, stronger, and present a better appearance. Each stone should be of sufficient width to overlap the stone below at

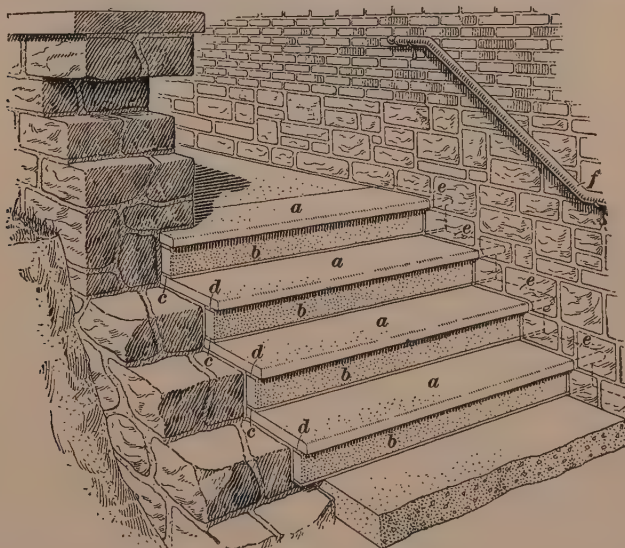


FIG. 24

least 2 inches, and thus permit of bedding each stone with mortar along its entire length.

In Fig. 23 the stone steps are set between the area walls and the foundation walls, and rest on stones which project beyond the face of the foundation wall, as shown at *b*, and beyond the area wall, as shown at *c*.

Slabs forming steps, such as shown in Fig. 24, should not be less than 2 inches thick and should be sufficiently wide to form a bearing for the riser at the back of the slab at *c*, and a nosing over the riser at the front of the slab at *d*. Steps of this character should be constructed while the walls of the area and building are being erected and the slabs should be extended into these walls, as indicated at *e*, to make them secure.

All stones forming treads of steps should be set with a slight slope downward toward the front to drain away water from the

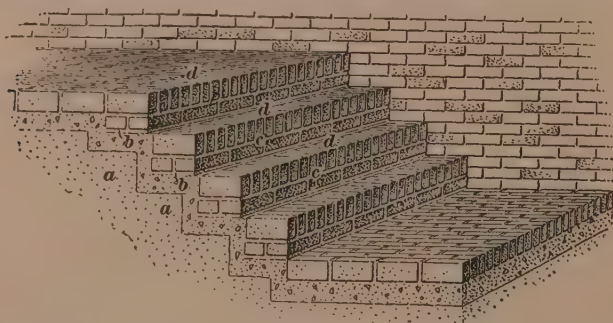


FIG. 25

surface, and the edges of the steps should be slightly rounded, otherwise they may become chipped.

26. Brick Steps and Brick Risers and Stone Treads. Steps formed entirely of brick, as shown in Fig. 25, or steps formed with brick risers and stone treads, as shown in Fig. 26, are often used for entrances to cellars of suburban residences.

Brick selected for these area steps should be hard burned so that they will not absorb moisture, especially when the steps are to be built in a locality that is subject to freezing weather, as otherwise they will deteriorate. Brick that have a slightly rough surface are preferred when used for the treads, to those that are smooth, as they afford a better footing and do not become slippery when wet.

Only rich cement mortar should be used in the construction of these steps so that the joints of mortar may also be impervious to moisture. Both brick and stone should be well bedded in the mortar and the joints carefully pointed with a trowel.

Brick steps may be constructed directly on the soil in localities that are not subject to freezing weather. The soil should be leveled under each step, as shown in Fig. 25 at *a*, to form a surface on which a bed of mortar or concrete *b* may be placed to receive the brick.

In localities having freezing weather, steps should be provided with a subbase of cinders, usually from 6 inches to

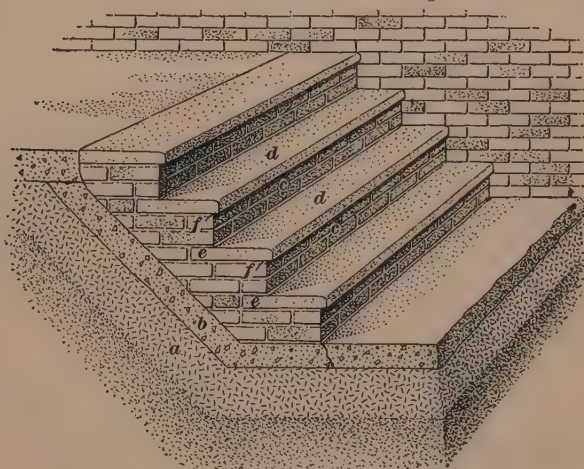


FIG. 26

8 inches deep, as shown in Fig. 26 at *a*, and a base *b* of concrete about 4 inches thick, to form a foundation for the brickwork.

The steps shown in this illustration are formed of brick risers and stone treads. Two courses of brick, which are laid on their flat face, form the risers *c*, and the treads *d* are of stone slabs of the same character as for the built-up stone steps shown in Fig. 24. These stone slabs should be of sufficient width to form a bearing for the brick riser, as shown in Fig. 26 at *e*, and a nosing over the brick riser below, as shown at *f*. All treads formed of brick or stone should be set to form a slope for the drainage of water from the surface, and the edges of

the stone treads should be rounded as previously described for stone steps.

27. Concrete Steps.—Concrete is a very good material for area steps and is used extensively for the reason that sand, gravel, and broken stone are available in nearly all localities.

Concrete steps are made by erecting wooden forms of the size and shape desired for the steps and filling these forms with concrete.

In Fig. 27 is shown a form of construction where the entire

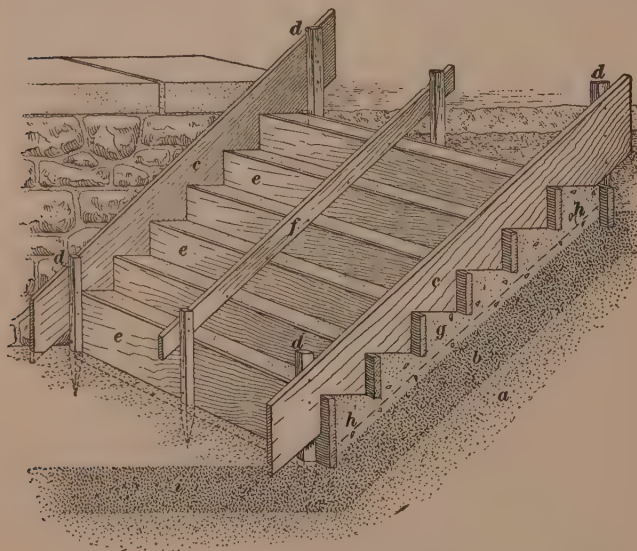


FIG. 27

right of steps rests on a soil foundation. Excavations for these steps are made on a sloping plane, as shown at *a*, and on this plane a cinder bed or foundation *b* is installed to form a drainage for water, this being necessary for steps that are exposed to freezing temperatures, in order that no water may collect under the steps and freeze. In warm climates, and where the excavations are in sand or gravel, this cinder bed may be omitted. If the soil is not sufficiently firm to retain the sloping surface above described a wooden platform having a

similar slope may be installed to receive the cinders or the concrete base.

28. To construct these steps, forms must be provided for each step to hold the concrete at the various heights required. These forms are usually constructed with plank stringers, as shown in Fig. 27 at *c*. These stringers are placed at the sides of the area and held in place by means of wooden stakes *d*. The stringers are cut on the under side to the required shape of the steps, and boards or planks *e* are fastened to the stringers to form the risers of these steps. The boards *e* are usually reinforced at the center by means of a timber *f*, to which each board is securely nailed. This timber prevents the boards *e* from bulging out when the concrete is placed. Stringers should be located sufficiently high so that the concrete will extend beneath them and form a continuous slab of concrete under the entire flight of steps, as shown at *g*. This slab is usually reinforced with small steel rods or a coarse wire mesh *h*, which distributes the load throughout the slab and resists the expansion and contraction of the concrete which might otherwise cause the concrete to crack.

29. Concrete steps may be cast in their final form or in such a manner that a finishing coat of cement mortar may be applied after the forms have been removed. If a finishing coat is to be applied the treads should be made about 1 inch lower than the finished levels and the face of the riser should be formed about 1 inch back from the finished face as designed.

After these forms have been completed and the steel reinforcing rods have been placed, the concrete is deposited, the lowest step being poured first and then each step separately in order until the entire flight of steps is cast. While concrete is being filled into the forms the steel reinforcement should be raised slightly to make sure that it is entirely surrounded by concrete.

Concrete for this construction should have the various ingredients worked together so as to form a uniform mixture. Sufficient water should be added to wet all of these ingredients, but not enough to cause the mass to be so soft that the concrete

will be pushed out of the lower part of the forms by the weight of the concrete that is placed in the upper parts.

30. When the concrete has set, the forms may be removed. If no final coat is to be applied the steps should be carefully examined and defective places repaired and the edges of the treads slightly rounded. This rounding may be accomplished by rubbing the edges with a piece of sandstone and keeping the concrete wet during the operation.

If a finishing coat of cement-and-sand mortar is to be applied to the steps, the repairing above described will not be required, as any roughness in the concrete will serve to help bond the concrete and surfacing mortar together. Before applying the surfacing mortar, however, the rough concrete should be thoroughly cleaned and wet with water so that the surface coating will adhere. It is customary to finish the surface of the treads somewhat rough to insure a secure footing, but the risers may be finished either rough or smooth as desired.

31. The flight of steps shown in Fig. 28 is of concrete that is reinforced with steel bars, as shown at *a* and *b*, and spans the distance between the soil bearing at *c* and the area-wall bearing at *d*.

The steps are constructed after the area walls have been completed, and require wooden forms on which the concrete may be placed and supported until the concrete hardens. These forms are left under the steps, as they cannot be removed after the concrete has been poured, but the decay of the wood will not affect the strength of the steps as they will be self-supporting when the concrete becomes hard.

The forms are constructed as follows: The posts *e* are placed at the top and the bottom of the flight, and on these are placed the timbers *f*, which run parallel with the sloping steps. The ends of these timbers are nailed to the posts. Crosspieces *g* are fastened to these timbers and the boarding is placed on the cross timbers as shown at *h*. Wedges *i* should be provided and placed under the posts *e* to permit of proper adjustment of the forms to the lines desired. The forms that are required

to make the treads and risers of the steps and the manner of forming these steps are similar to those described for the steps shown in Fig. 27.

The surface of these treads may be made rough to secure a safe footing, or metal plates that are made of a material that affords such a footing may be installed as shown at *j* in Fig. 28. These plates should be set flush with the surface of the tread.

All concrete steps that are constructed in hot weather should be kept moist for several days after the forms have been

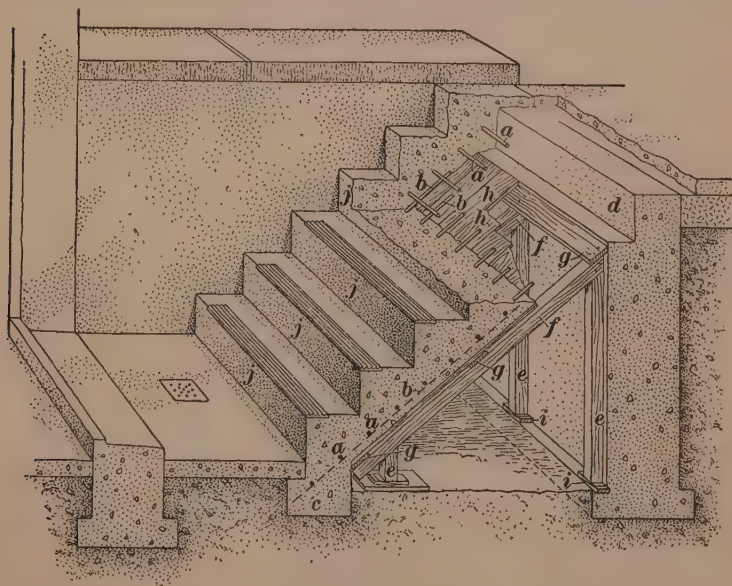


FIG. 28

removed and those which have a special finishing coat should also be similarly treated after the coating has been applied.

32. Marble Steps.—Marble selected for steps should be of a variety that is hard and dense and free from seams that may open and permit water to penetrate the slab. The treads should be not less than $1\frac{1}{2}$ inches in thickness and if they exceed 4 feet in length should be at least 2 inches thick. Risers may be 1 inch in thickness if so desired. Marble for this construction is usually finished with a smooth dull surface.

The marble slabs are usually assembled and installed in the same manner as thin slabs of stone. The ends of the slabs, however, are not extended into the walls at the sides, but require masonry to be built to support them. The steps are not installed until after all structural parts of the building have been completed.

Marble treads are sometimes equipped with metallic plates, of the same character as described for concrete steps, to afford a secure footing, as marble treads become very slippery when they are wet. A hand rail, as shown in Fig. 24 at *f*, is sometimes installed on a wall adjoining such steps to be used as an additional safeguard.

Marble steps require to be very carefully constructed and must be secured to the foundations in the most thorough manner to insure their permanence. Each slab should be carefully bedded in mortar to secure a level and even bearing, otherwise the slabs will break.

Marble slabs used for treads of iron stairs usually rest on metal shelves that are formed on the stair frames, and the slabs may be bolted to the metal work or cemented in place.

33. Iron or Steel Stairs.—Stairs made of iron or steel are usually constructed with treads and stringers but no risers, and the treads are finished with a rough surface to secure a safe footing, or metal plates as previously described are attached for this purpose.

AREA FLOORS

34. It is the usual practice to install floors in all uncovered areas to protect the foundations of the area walls and to keep the walls of the building dry. In areas designed as a means of access to basements the floor also forms a pavement between the area steps and the entrance door, as shown in Fig. 10 at *e* and in Fig. 14 at *c*.

Floors of areas in front of basement windows should be below the window sills, and floors of areas used as entrances to basements should be similarly placed below the door sills.

All area floors should be formed with a slope that will cause the water to flow to the opening in the floor provided for drainage, as shown at *e* in Fig. 8, at *f* in Fig. 10, and at *d* in Fig. 14. Areas that have a sand or gravel foundation frequently have the floor omitted, as these materials afford a natural drainage for the water. Floors are also frequently omitted in covered areas of the type shown in Fig. 16, except where the soil is of a character that prevents water drainage, when a floor will be required.

Excavations for floors should be made to the depths necessary for the foundations and the floor construction. If the soil is dense and water does not drain away freely, a 6-inch bed of cinders or gravel should be installed to provide drainage that will protect the floor. Area floors are usually constructed with a concrete foundation and a surface of cement-and-sand mortar. These floors are durable and impervious to water and are also easily installed. Brick and stone were formerly used very extensively for area floors, but these materials have been supplanted by concrete, except in localities where the stone or brick are more easily obtained than sand or gravel.

The construction of area floors of brick, stone, or concrete is the same as that required for the construction of sidewalks, which is described later on in this Section.

If marble or tile is used for an area floor, a concrete foundation not less than 4 inches thick should be installed on which a cement mortar should be spread to receive the floor material. All joints between the marble slabs or tiles should be filled with the mortar.

AREA DRAINS

35. The purpose of the area drain is to carry away the water from the area floor. This drain usually consists of a receptacle, which collects the water, and drain pipes which connect this receptacle with the drainage system of the building.

In large areas, such as shown in Figs. 8 and 10, where considerable water enters during a heavy rainfall, the receptacle usually installed is of the type shown in Fig. 29, which is called

a *catch basin*. This basin is sometimes made 2 feet or 3 feet in depth, and thus forms a reservoir where the water may collect before it enters the drain, and it also permits sediment to collect which might otherwise enter the drain and cause a stoppage in the pipe.

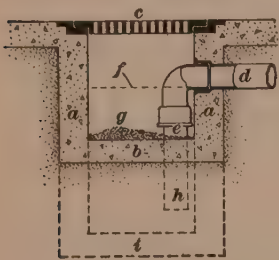


FIG. 29

These catch basins are constructed with walls *a* which are usually of masonry or concrete, and a floor *b* of concrete, and the entire basin is so constructed that it will hold the water. The top of the basin is provided with a cast-iron frame and movable grating *c*, to give access to the basin when required to clean out the dirt that collects on the bottom. The drain outlet *d* is placed near the top of the basin and the inlet into this pipe, as shown at *e*, is located near the bottom. This inlet should be a sufficient distance above the floor to allow the sediment to collect and also to permit some water to remain in the basin and thus form a seal that will prevent sewer gas escaping from the sewage system of the building. The dotted line *f* shows the level at which water will stand in the catch basin.

If the catch basin is deep, as indicated by the dotted lines at *i*, it will be necessary to extend the inlet pipe to *h*, allowing a space below the end of this pipe as described above.

36. As the water in the basin may evaporate during the summer months, however, and thus permit sewer gas from the house sewage system to escape, the plumbing regulations of cities usually require that the discharge line from the area drain be connected into a rain leader, behind the leader trap, as this trap, being quite large, will hold sufficient water at all times to form the seal necessary to prevent the escape of the sewer gas. A

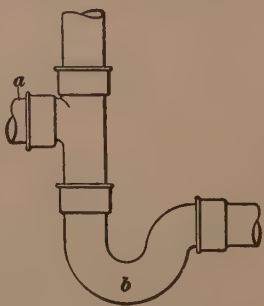


FIG. 30

leader of this character is shown in Fig. 30, the catch-basin drain entering it at *a*. The leader trap is shown at *b*.

Cesspools, such as are shown in Fig. 31, may be used as receptacles in small areas. These cesspools are usually made of cast iron and can be obtained in various sizes. They are provided with a hinged or movable grating *a*, to permit of cleaning out the dirt that collects at *b*. In some cities the plumbing regulations permit drains from cesspools to discharge into the sewage system

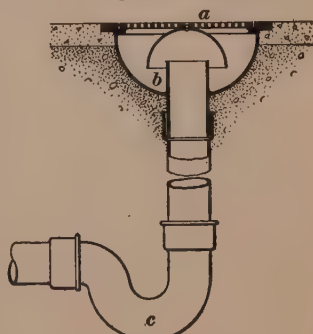


FIG. 31

of the building provided the connection is not less than 4 inches in diameter and a separate trap *c* is installed below the cesspool to form the water seal.

BALUSTRADES, RAILINGS, GRATINGS, AND COVERS

37. Balustrades and Railings.—Large deep areas are usually enclosed with a balustrade of the form shown in Fig. 8 at *f*. The posts of these balustrades are usually made of cast iron. The rails and balusters are made of plain rolled steel shapes, or of cast iron when an ornamental design is desired.

A railing of the form shown in Fig. 14 at *e* is most commonly used for enclosing areas that provide a means of access to basements. This railing is formed of pipe cut to required lengths and put together by means of special fittings. The pipe used for the posts is usually slightly larger than that used for the rails.

All posts of cast-iron balustrades and pipe railings should be set into the coping and wall to a depth of at least 6 inches, and should have melted lead run around them to fill the remaining part of the opening in the stone so as to form a secure installation.

38. Gratings and Covers.—Small window areas are usually equipped with a grating as shown in Fig. 19 at *e*, although a railing may be used if so desired. These gratings are usually made in one piece, but if the area is large and it is desired to have access to it, the grating may be made in sections, which are hinged to the frame as shown in Fig. 22 at *c*.

Hinged gratings of this character are sometimes used for sidewalk areas where not prohibited by the local building code, but as these gratings permit dirt to pass through them, the areas become unsanitary and for this reason solid doors should be used. The covering shown in Fig. 32 has doors *a* formed of

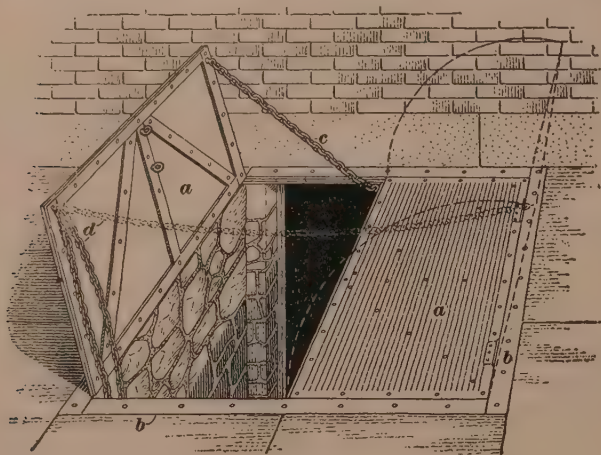


FIG. 32

sheet steel, finished with a rough top surface so that pedestrians may not slip on them. These doors are hinged to an angle-iron frame *b*, which is securely fastened to the sidewalk. They are also provided with chains *c* or some other device that will hold the door open and in such a position that the doors will form the necessary protection at the sides of the opening. The front of the opening usually has a guard chain *d* which can be connected across the opening at the front edges of the doors when they are open, as indicated by the dotted chain. The doors and hinges are designed to be flush with the surface of the sidewalk when installed.

39. In suburban districts, areas that are used for entrances to basements or cellars are frequently covered with wooden doors, as shown in Figs. 16 and 17. Such a covering is called a **bulkhead**, and is constructed with a wooden frame *a*, Fig. 16, which is securely fastened to the plates *d*, Fig. 17; and a head-piece *c*, Fig. 16, is provided to keep out the rain and snow and also to receive the top edges of the doors *b*. The doors should be of tongued-and-grooved boards securely fastened to battens *d*, and should have strong strap hinges and a padlock for fastening.

VAULTS

SIDEWALK VAULTS

40. Definitions.—In large cities where land is expensive and space is consequently valuable, the cellar or basement of a building is often extended beyond the lot line on the street front in order to utilize the space under the sidewalk. This extra space is called a **sidewalk vault**, or a *vault*.

The vault usually extends to the line of the street curb and also to the depth of the basement of the building. Buildings having a subbasement usually have a vault that extends to the floor of this subbasement and the vault is divided into stories to correspond with the basement and subbasement of the building. Sometimes the basement floor of the vault is omitted and the vault is used as a shaft for the purpose of lighting and ventilating the subbasement.

41. Building Laws.—In nearly all cities the construction of vaults under sidewalks is permitted. The building codes usually require, however, that the walls of the vault be constructed of stone, brick, or concrete, and be designed to be amply strong to resist the pressure due to the adjoining soil. The roofs are required to be of incombustible materials, and amply strong to carry the loads that they are to bear. Suitable openings must be formed in the roof, and devices installed in these openings whereby the vault may be ventilated.

There are some special requirements relating to vaults that apply only to certain localities, and the architect or contractor should familiarize himself with the local building code and these local requirements before preparing his plans and specifications, in order that the work may be designed to conform with the law.

42. Description and Uses.—Sidewalk vaults may be entirely enclosed by walls, the foundation wall of the building separating them from the basement, or they may be almost entirely open on the side toward the building and thus form an extension of the basement.

A vault that is practically enclosed is shown in Fig. 33. The wall that separates the vault from the basement is shown at *a*, an opening that permits of access to the vault is shown at *b*, the wall that retains the soil and roadway in place at *c*, the roof construction with the finished sidewalk at *d*, and the floor at *e*. The wall *c* is sometimes called a retaining wall although it is not a true retaining wall since it is braced at the top by the sidewalk construction.

Walls at the ends of the vault are sometimes called end or side walls, and when a vault is separated from an adjoining vault by a single wall that is so located that one-half of the wall is on one property and one-half on the other property, the wall is said to be a *party wall*.

Vaults of this kind are generally used for the storage of coal or merchandise, or as a means of taking goods into the basement, consequently they are generally provided with a coal-hole cover and frame, as shown at *f*, hinged doors of steel or iron *g*, and sidewalk ventilators *h* to admit air to the vault.

43. A vault that is entirely open on the side toward the building is shown in Fig. 37. The piers which support the upper portions of the building, as shown at *a*, form the only obstruction between the vault and the basement. The curb wall at *b*, the sidewalk at *c*, and the floor *d*, each serve a purpose similar to corresponding parts of the vault previously shown.

Vaults of this character may be used for any purpose to which the basement of the building is devoted, and the vault is

usually finished in a manner that will correspond with the basement.

Sidewalk vaults of office buildings are frequently used for some part of the mechanical equipment of the buildings, such as motors and pumps that supply water to the plumbing fix-

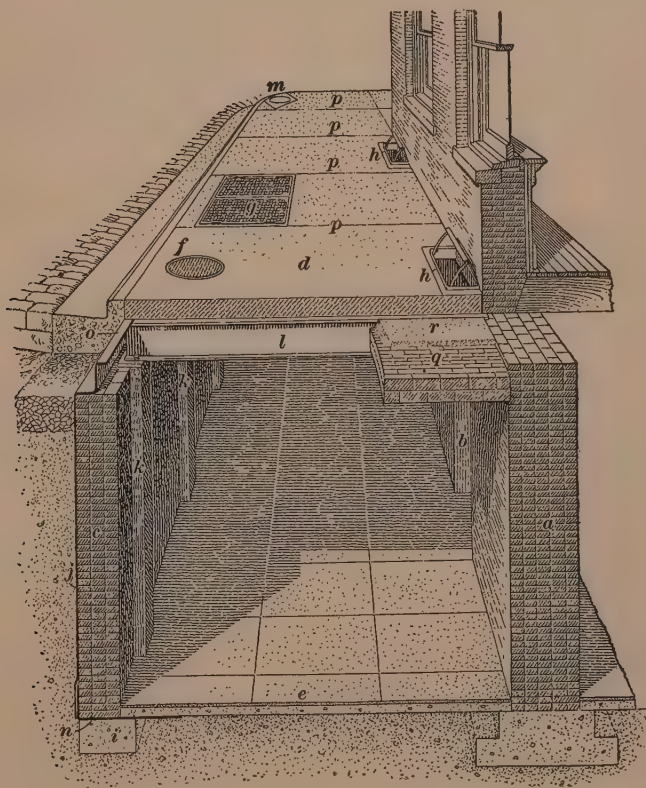


FIG. 33

tures, motors that operate the vacuum sweeper system, or for the sidewalk lifts and elevators.

In mercantile buildings where the basement is frequently used for the sale of merchandise, ventilators of the type shown at *e*, and sidewalk lights as shown at *f*, are installed to provide air and light for the vault and the adjoining parts of the base-

ment, thus making the vault a most valuable addition to the floor space of the basement.

In this illustration, a part of the basement is devoted to the heating apparatus and a part of the vault to the storage of coal. The heating boiler is shown at *g*, the coal hole in the sidewalk at *h*, the coal bin at *i*, a fireman's ladder at *j*, and small doors in the sidewalk at *k* for access to this ladder, this being required by some codes to provide means of exit from the basement in case of fire. At *l* are shown sidewalk doors through which ashes may be removed from the basement by means of a sidewalk lift or a crane.

WALLS OF VAULTS

44. Excavations.—In making excavations for vaults, sufficient space should be provided not only for the walls and footings, but also to perform other operations, such as bracing the soil, pointing and waterproofing the wall. If the soil is not firm, braces consisting of strong timbers and plank should be installed to prevent the soil surrounding the excavated space from breaking away and falling. This bracing is of the greatest importance if the vault is to extend to the curb line, as the breaking of the roadway and the soil beneath it may injure municipal gas and water pipes that are frequently located adjacent to the curb and thus cause serious damage.

45. Construction.—Walls of vaults are built of stone, brick, plain concrete, or reinforced concrete, the choice of material depending upon what is most easily available in the locality where the vault is to be built, its cost, and sometimes upon the material which is used in building the foundation walls of the building. If the walls are of brick or stone, they should be laid in cement mortar. The materials should be well bonded together, the joints and crevices thoroughly filled, and the face of the mortar joints carefully pointed to prevent water entering the wall. If the wall is of concrete, both faces should be finished smooth and free from openings or pores through which water might enter.

It is the general practice to provide footings under all vault walls except where the soil is very hard or where rock is encountered. The size of the footing should be determined by the bearing value of the soil, a larger footing being required on a soil that is soft than on one that is hard and compact. These footings may be formed either of large flat stones or of concrete, the material used in the wall usually governing that used for the footing.

46. The curb wall shown in Fig. 33 at *c* has a footing *i*. This footing is located below the bottom of the floor slab so that the waterproofing material *j* may connect with the waterproofing under the edge of this floor slab as shown.

This curb wall is reinforced by means of pilasters *k*, and the top of the wall is braced against the wall of the building by means of the vault roof beams, one of which is shown at *l*. Walls that are reinforced and braced in this manner need not be so thick to resist the lateral pressure of the adjoining soil as walls that have no piers or braces.

47. In Fig. 33, the cover of a catch basin, which is located at the intersection of two streets, is shown at *m*. As the vault walls must be constructed in a special manner to receive a catch basin, details of the basin

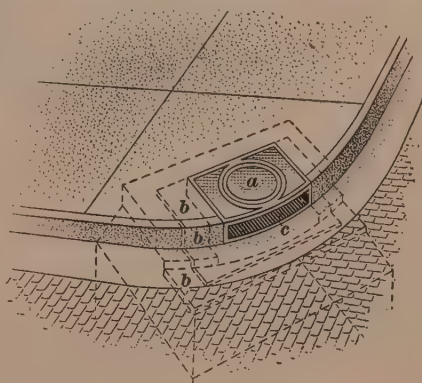


FIG. 34

and its relation to the vault walls are shown in Fig. 34. The cover of the basin is shown at *a*, and the dotted lines *b* show the cast-iron frame, which rests on the masonry walls of the basin and is concealed under the sidewalk. As *c* is shown the inlet where the water enters the basin. Some cities have standard sizes for the various parts of these catch basins, and the architect or contractor should secure the necessary information from the proper authorities that will enable him to determine the

correct size and dimensions for the recess that is required to be formed in the vault walls in which the basin is to be set.

48. The vault shown in Fig. 35 is similar to the one shown in Fig. 33, inasmuch as it is separated from the basement of the building by a wall *a*, in which there is an opening *b*, for access to the vault. In this figure is also shown a curb wall at

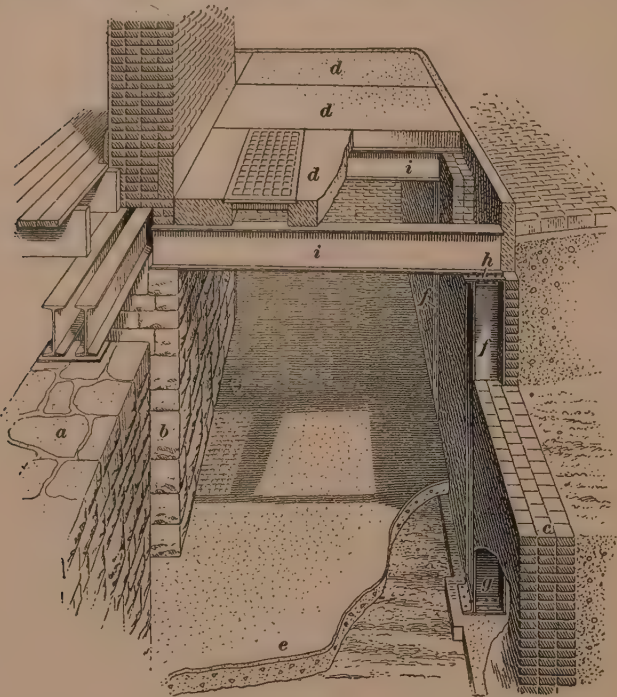


FIG. 35

c, a sidewalk at *d*, and a floor at *e*. The curb wall, however, is reinforced by means of steel I-beam columns *f*, instead of brick pilasters.

In the construction of this wall the steel columns are set back from the outer face of the wall about 4 inches so that a course of brick may be installed to protect the face of the column. The foot of the column has a base *g* that is anchored to the footing of the wall by means of bolts, and the top of the

column is secured to the roof beams *i* at *h*. In this form of construction the brick wall is reinforced by the steel columns and thus resists the pressure caused by the adjoining soil. The anchoring of the column to the footing of the wall prevents any slipping of the column at the bottom, and the top of the column is braced by the sidewalk beam *i*.

Curb walls of this construction are often used for vaults that extend to the depth of the subbasement of a building, the sidewalk beams *i* and curb-wall columns *f* being usually spaced about 4 or 5 feet apart. In Fig. 36 the wall columns are shown at *a*, and the walls are in the form of arches *b*. For these deep vaults, however, additional steel-beam braces, similar to the roof beams *i*, Fig. 35, are usually required. They are placed at the level of the basement floor and at the bottom of the curb-wall columns, opposite to the steel columns of the building, to resist the excessive pressure due to the high bank of soil that the wall has to retain in place.

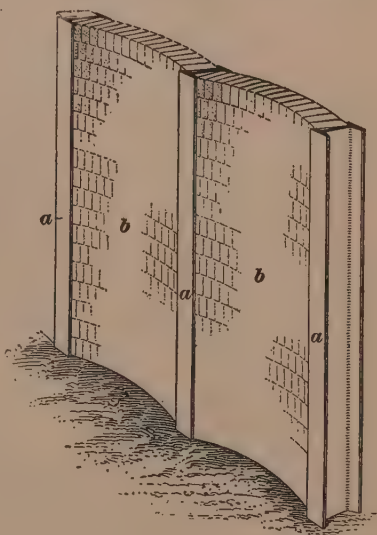


FIG. 36

49. In Fig. 37, the curb wall is shown to be made of plain concrete and is formed with a sloping inside face. A city fire hydrant is shown at *m*, the lower portion of which is installed in a recess formed in the curb wall. These recesses are required by the building codes of some cities in order that the hydrant and all pipes and fittings may be accessible from the roadway. Details, showing one form of construction of the curb wall at this hydrant, are shown in Fig. 38. In (*a*) the vertical section through the recess is shown at *a*, the space around the hydrant being filled with soil after the water connections to the hydrant have been completed. At *b* is shown

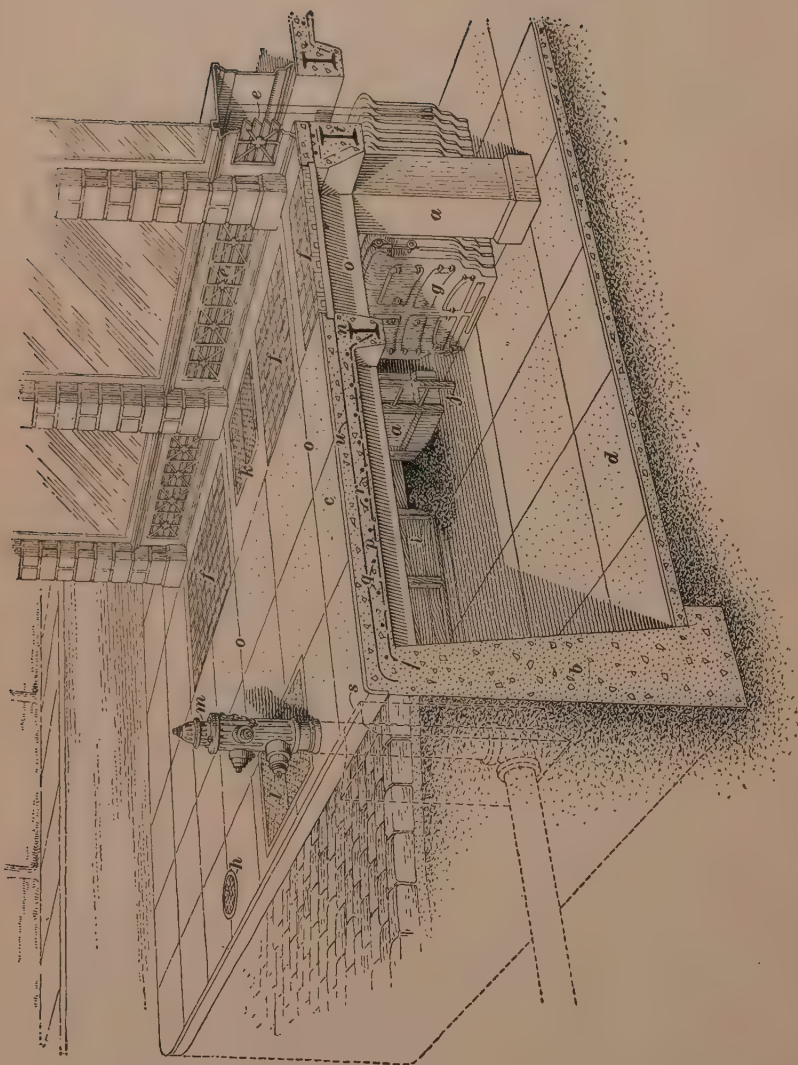


FIG. 37

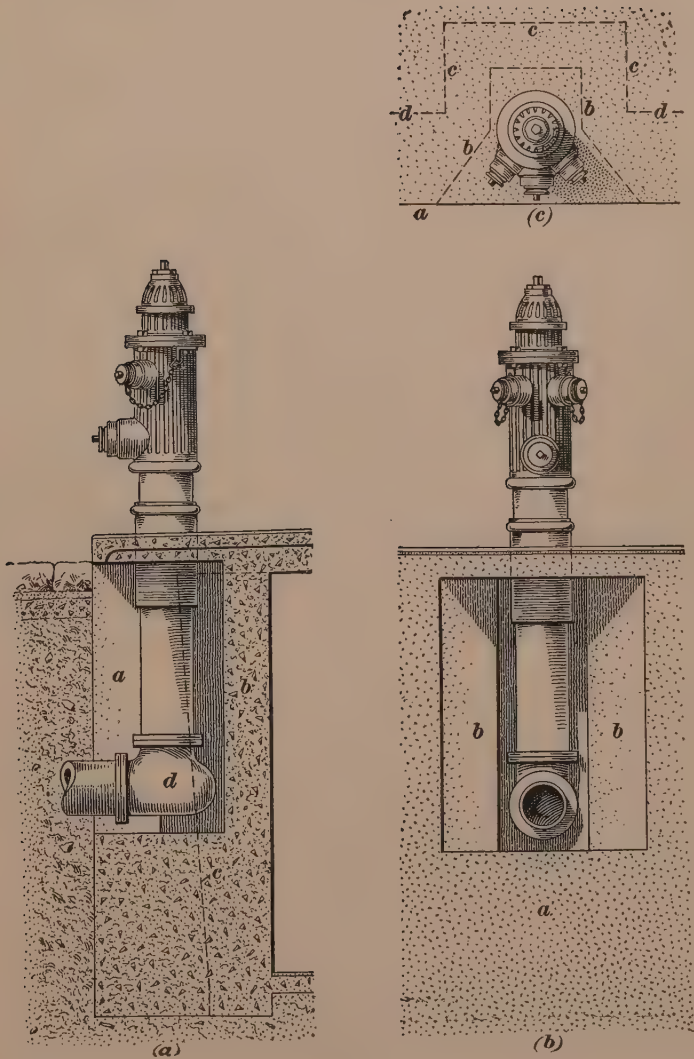


FIG. 38

the wall back of the recess, and the dotted line *c* shows the back of the regular curb wall at either side of the part which forms the enclosure for the hydrant.

A front view of the hydrant is shown in (*b*), the curb wall being indicated by *a* and the recess by *b*. A plan of the hydrant is shown in (*c*). The face of the wall is shown by the solid line *a*, the recess for the hydrant by the dotted line *b*, and the outline of the wall back of the recess by the dotted lines *c*. The regular curb wall either side of this specially formed part is shown by the dotted lines *d*.

The depth to which the recess is carried below the roadway will depend upon the climate of the locality where the work is to be done. The supply line to the hydrant and the valve that controls the water supply, which is located in the fitting *d*, in view (*a*), should be placed below frost line.

50. Waterproofing.—Frequently it is necessary to waterproof the outside face of the vault walls to insure the vault's being kept dry. This may be accomplished by coating the wall with hot pitch or by covering the wall and the footing with tarred felt, burlap, or other similar fabric, which is cemented to the wall by means of hot pitch. This latter method is shown in Fig. 33 at *j* and *n*. In both of these methods the wall coating of pitch should be applied in such a manner that all crevices in the wall are completely filled. If the felt or fabric is used it should be applied while the pitch coating is hot, to insure its adhering to the wall. The felt should overlap at the joints and these parts also should be cemented together by means of the pitch. This process is repeated with additional layers of felt until at least three thicknesses have been applied.

In this method of waterproofing it is customary to install the layers over the footing, as shown at *n*, before the wall is built, and these layers are made sufficiently long so that after the wall has been completed they may be turned up against the face of the wall and cemented in place. When the felt is applied to the face of the wall, as shown at *j*, it should overlap this footing covering, which has been turned up, and be

thoroughly cemented to insure a waterproof joint of the two parts. At the top of the wall the felt should be carried up behind the curb to the level of the under side of the sidewalk slab, as shown at *o*, and be cemented to the part of the masonry back of the curb.

ROOFS

51. The roofs of vaults are of two types. One type has a framework of steel or reinforced-concrete beams, with panels of brick, tile, or concrete formed between the beams to serve as a foundation for the sidewalk.

The second type has a similar framework, but the sidewalk material spans the space between the beams and forms the roof of the vault.

A vault roof construction of the first-mentioned type is shown in Fig. 33. The framing consists of steel beams which extend from the curb wall to the foundation wall of the building, one beam being shown at *l*. Other beams of similar character are located at points marked *p*, and are spaced about 5 feet apart. These beams should be so set that they will slope toward the curb wall and be parallel with the sloping surface of the finished walk. In this illustration, brick arches are used between the beams to receive the sidewalk, a section through one of these arches being shown at *q*.

Hollow fireproofing tile is often used for arches between sidewalk beams and is a most satisfactory material for this purpose. When tile is so used, the beams may be spaced somewhat farther apart than they would be for arches formed of brick, as the tile is in larger pieces, is very light in weight, and is adapted to large spans.

In the construction of vault roofs of the brick or tile arch type, temporary wooden forms and supports will be required on which to place the roof materials, and these forms should provide suitable openings in the roof for the installation of ventilators, coal holes, door, etc. Only cement mortar should be used in the construction of brick or tile arches and the joints in these arches should be completely filled with the mortar and

carefully pointed to form a suitable surface to receive waterproofing materials.

When plain concrete is used between the beams it is generally installed in the form of an arch on the under side while the top is formed level with the steel work.

A vault roof of the second type of construction is shown in Fig. 35. This roof consists of a framework of steel beams, as shown at *i*, and a sidewalk of flagstones *d* that span the distance between the beams. The beams should be accurately set both as to height and slope so that the desired levels for the sidewalk may be obtained. The construction of these sidewalks is more fully discussed later in this Section under the heading of Sidewalks.

52. Reinforced-concrete construction is sometimes used for a vault roof that has a framework of steel, as shown in Fig. 37. Parts of the steel frame are shown at *n* and *t*, and these beams connect with other beams at *o* that extend from the curb wall to the piers of the building. A roof slab which spans between the steel beams and on which the sidewalk is laid is shown at *p*, and the reinforcing bars of this slab are shown at *q* and *r*. In this illustration the steel beams are enclosed in concrete, which produces a very neat and finished appearance and protects the beams from fire. Reinforced-concrete beams may be used if so desired in place of the steel beams *n* and *t*. Their size and that of the steel reinforcement will be governed by the length of the beams between supports and the load they are required to carry.

53. Waterproofing.—Vaults of the type of construction shown in Figs. 33 and 37 often have the top surface of the roof waterproofed, as at *u* in Fig. 37, before the sidewalk material is installed, to prevent water entering the vault. The materials and the systems described for the waterproofing of the curb walls may also be used for treatment of the vault roof. The roof, however, should be carefully cleaned before the coating is applied.

FLOORS

54. Floors of vaults are usually made of concrete and are laid and finished to correspond with the floor of the basement of the building. Vaults that are used for the sale of merchandise or other purposes that require the public to use the vault often have floors of wood.

Concrete floors require a concrete bed on which is placed a top coat to form the desired finish. These floors are constructed and finished in the same manner as sidewalks, which are described later in this Section.

If a wooden floor is to be installed, there should be a bed of concrete laid on the soil to prevent moisture from entering into the wooden flooring and causing it to decay. This concrete bed should be from three to four inches in thickness, with the top surface leveled and partially smoothed. On this concrete, wooden beams, called *sleepers*, are placed. They are usually spaced 16 inches on centers and the flooring is secured to them.

SIDEWALKS

GENERAL DESCRIPTION

55. Definition and Purpose.—A sidewalk is a prepared footway placed at the side of a roadway for the use of pedestrians, and is usually separated from the roadway by a curb and gutter. It is generally finished with a hard, durable surface consisting of brick, stone, or concrete, and is formed with a suitable slope so that rainwater will run off it readily.

56. Building Laws.—As sidewalks are used extensively by the public, the building laws usually define the details of construction that are considered necessary to make them safe for the use of pedestrians. Some of the requirements that are common to many of the codes are the following:

Sidewalks over vaults shall be designed to be of sufficient strength to sustain safely the live load that they are required to carry.

Sidewalks shall be formed with a slope to drain away water. This slope shall not be greater than $\frac{1}{4}$ inch to 1 foot.

Sidewalks shall be formed with a rough surface that will afford a secure footing for pedestrians.

In addition to code requirements there are often city standards for the construction of sidewalks that also must be complied with.

57. Classification.—Sidewalks may be classified into two groups; those that rest directly on the soil or on a foundation which provides a uniform bearing throughout, and those which have bearings only at intervals and which are constructed of materials that will span the distance between these bearings and carry the required loads.

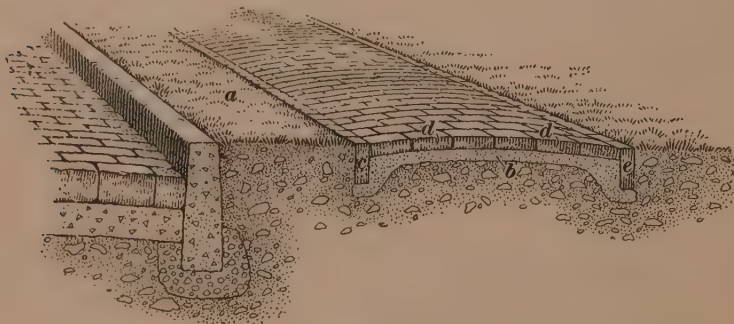


FIG. 39

Sidewalks of the first-mentioned class are illustrated in Figs. 33, 37, 39, and 40. In Fig. 33 stone slabs are supported upon a foundation formed by the brick arches *q* and the sand or concrete fill *r*. In Fig. 37 the sidewalk is of concrete placed on top of the waterproofing on the concrete slab below.

A sidewalk of the second type is shown in Fig. 35, where stone slabs of sufficient thickness and strength are supported on the steel beams and span the distance between the beams as well as support the superimposed load.

The widths of sidewalks vary according to the requirements of the locality where the walks are to be laid. In residential or suburban districts where there is very little traffic, the walks are usually made from 4 feet to 6 feet in width, and a space is

often provided between the walk and the curb to form a grass plot, as shown in Fig. 39 at *a*. In business districts of cities, however, where there is a great amount of traffic, it is necessary that the walks be wide, and they are usually made to occupy the entire space between the curb and the building or lot line which they adjoin, as shown in Fig. 41.

CONSTRUCTION

58. Brick Sidewalks.—In residential or suburban districts and where the climate will permit of the use of a shallow bed of sand for a foundation, brick sidewalks are usually constructed as shown in Fig. 39. The excavations are carried to a depth of from 6 inches to 8 inches below the grade levels, and sand is placed in these excavations and leveled to form a uniform bed 2 inches thick, as shown at *b*, on which to place the brick.

At each side of the walk trenches should be formed below the regular excavations to receive the bricks set on end as shown at *c* and *e*. These bricks form a border for the walk and help to retain the bricks of the walk in place.

The bricks *d* should be so placed that there will be joints on all sides uniformly $\frac{1}{2}$ inch wide. After all of the bricks of the walk have been placed, the walk is covered with sand and this is brushed into the joints until they are entirely filled, after which the superfluous sand is removed.

In this illustration the bricks are laid with the broad flat surface exposed. They may be laid, however, with the long thin face exposed, or some of the bricks may be laid flat and some on the thin edge to form a pattern if so desired.

When the soil adjoining a walk of this character is level instead of sloping toward the street curb, the sidewalk is usually formed slightly higher in the center than at the sides, to form what is called a *crown*, so that the water will drain toward each side.

59. In localities subject to freezing temperatures, brick sidewalks for residence districts should be constructed as

shown in Fig. 40. In this illustration, the subbase of cinders which permits the water to drain away is shown at *a*, the concrete base at *b*, and the bed of cement mortar, which is to receive the brick, at *c*. Trenches which are partly filled with cinders are sometimes formed between the cinder subbase and the adjoining curb foundation, as shown at *e*, to carry away the water from the cinder foundation. Such trenches are called *leaders*.

The subbase of cinders, the base of concrete, and the trench between the walk and curb foundation are frequently omitted where sand or gravel are encountered in the excavations, in which cases the surface of the soil must be properly leveled to receive the cement bed for the brick.

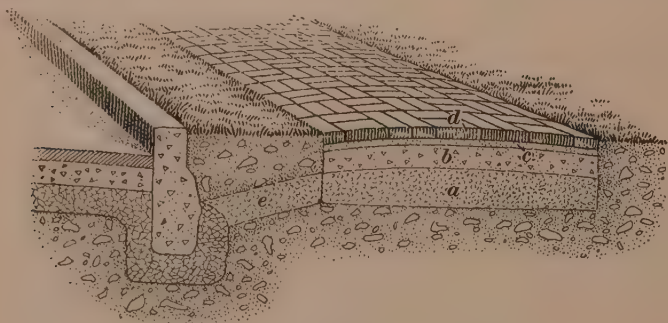


FIG. 40

The cinder subbase indicated is usually from 6 inches to 8 inches deep, although in extremely cold climates, and also where an excessive amount of water is encountered in the excavations, this base is sometimes made 12 inches deep. The concrete base is usually made about 4 inches thick and is formed of cement, sand, and gravel in the usual proportions. The cement bed for the bricks is made of cement one part and sand two to three parts, and is surfaced to the required levels by means of a straightedge used lengthwise of the walk. The leaders which drain the water away from the cinder subbase are usually located from 25 feet to 35 feet apart.

In the illustration, the bricks are laid on their broad flat face and alternate in direction to form a pattern. After the bricks have been laid in place they should be tested by means of a

straightedge and bricks that are too high should be rapped lightly with a trowel to bring them to the position desired.

After the mortar in which the bricks are bedded has become sufficiently set to hold them in place, the joints between the bricks should be filled with a thin cement mortar, and the surface of this mortar pointed with a trowel. Before the mortar has become hard, mortar stains should be removed from the face of the brick by using water and a steel brush, or a brush made of strong vegetable fiber.

60. All brick sidewalks in business districts should have a concrete foundation and the bricks should be set in a cement mortar bed to insure their being retained in place. The joints between the bricks should also be filled and pointed as previously described. To lay sidewalks on the roof of a vault, cement mortar should be spread over the roof construction and the brick should be laid in this bed and be leveled to the line of a long straightedge that will span the entire width of the walk.

Sidewalks in the business districts are usually not formed with a crown, but slope downwards toward the curb.

61. Stone Sidewalks.—Sawed or split slabs of stone make an excellent sidewalk and are used extensively where such material is easily obtained. The best stone for this purpose and one that is most generally used is bluestone, although any compact limestone or granite will answer the purpose. The objection to granite, however, is that it wears very smooth and thus becomes slippery when it is wet.

Flagstone sidewalks for residential districts are usually formed of slabs that extend the entire width of the walk. These slabs are from 2 inches to 4 inches in thickness and the edges that are to adjoin are cut true and even to form close joints. The edges that form the sides of the walk are usually not dressed, but after the walk is laid they are cut to a line on the surface, the remaining part of the edge remaining rough.

Foundations for flagstone sidewalks are usually made of sand or cinders, and the depth of this foundation should be determined by the climatic conditions of the locality where the walk is to be laid. A very shallow bed of sand will suffice

where there is no frost to affect the soil, but where cold weather occurs the bed should be from 4 inches to 12 inches deep to provide suitable protection for the walk. Leaders to drain away water from the cinder bed, as described for brick sidewalks, should be installed where possible.

62. Flagstone sidewalks for business districts are usually formed of large slabs so that there may be as few joints as possible. The slabs should be of ample thickness, as the excessive use of these walks causes the stone to wear away rapidly. Where these slabs form the roofs of vaults they are often made from 6 inches to 8 inches in thickness, this thickness being determined by the kind of stone that is used, the span between

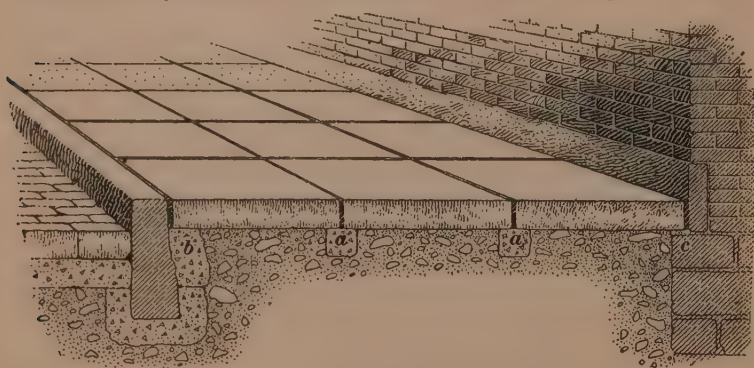


FIG. 41

the bearings, and also by the live load the slab is required to carry. Walks of this character when resting on soil should have foundations similar to those described for residential districts.

Wide sidewalks which are formed of a number of slabs should be provided with foundations that will maintain the slabs in a level position at all times so that one slab may not project above or settle below the one adjoining and thus cause pedestrians to trip and fall. Slabs laid on the soil may be maintained in position by installing shallow concrete walls under each joint as shown in Fig. 41 at *a*. Slabs that adjoin the curb should rest on the curb wall where such a wall exists or on a shallow wall as shown at *b*, while those which adjoin

the foundation of the building should rest on either the foundation wall, as shown at *c*, or a shallow wall similar to those installed at the joints.

63. Stone slabs for sidewalks when installed on a vault roof constructed as shown in Fig. 33 at *d*, should be provided with a bed of sand, as at *r*, on which the slabs may be placed. Sometimes concrete is used to fill over the arches and form this bed and also to secure a level surface on which waterproofing may be placed.

Stone slabs which rest on steel beams as shown in Fig. 35 require to be very carefully constructed to prevent the water from entering the vault below. These slabs should be of uniform thickness where they rest on the beam or wall to insure an even surface for the walk. Edges of the slabs should be cut true and even and the slabs set so that the joints will be uniformly $\frac{1}{2}$ inch wide.

All joints between stone slabs, also the joints at the curb and wall lines, should be carefully filled with oakum and cement mortar. The process consists of placing oakum in the joint and driving it down by means of a hammer and a thin tool until it forms a compact filling to within 2 inches of the top of the slab. The remaining part of the joint is then filled with a mortar that is rich in cement. Hot asphalt, or asphaltic cement, is sometimes used in place of the cement for the filling, but it does not have the wearing value of the cement and will require to be replaced every few years if these joints are to be kept waterproof.

64. Plain Concrete Sidewalks.—All plain concrete sidewalks are usually provided with a cinder, gravel, or broken-stone subbase except those which are formed on a vault roof construction. The thickness of this subbase, however, may vary from 3 inches to 12 inches, depending upon the climatic conditions in the locality where the walk is to be laid, the greater thickness being required in very cold climates.

Excavations for sidewalk foundations should be uniformly level. If soft places are encountered, the soft soil should be removed and the space filled with the subbase material or good

soil. If soil is used it should be tamped down until it is uniformly hard and level.

Concrete sidewalks over vault roofs are laid directly on the roof construction.

Where local building laws or city standards do not define the requirements for the construction of sidewalks, the following may be used:

Concrete for base of sidewalks should consist of one part of Portland cement, three parts of sand, and five parts of gravel or broken stone.

The gravel or broken stone should be of such size that it

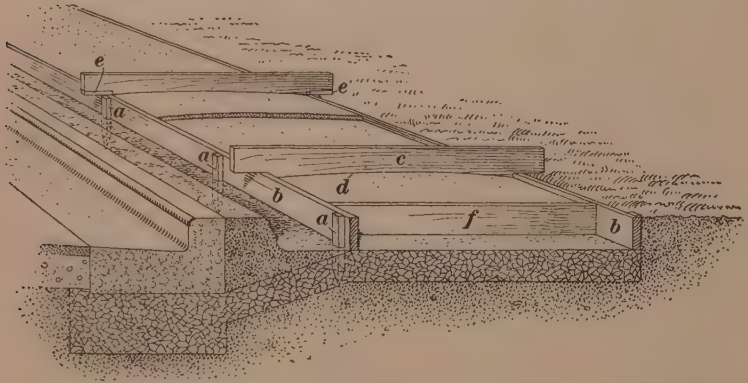


FIG. 42

will pass through a screen having a mesh of $1\frac{1}{2}$ inches in diameter. The base should be 4 inches in thickness.

The surfacing or top of sidewalks should be composed of one part of Portland cement and two parts of sand or clean sharp crushed granite or flint rock. This coating should be 1 inch in thickness.

Sidewalks should be laid off in blocks from 4 feet to 6 feet square, and the joints between these blocks should extend through both the top and the base.

65. All concrete sidewalks require *forms*, of wood or metal, to secure the desired shape and size. The tops of these forms are used as guides for the straightedge or templet when the surface of the sidewalk is being formed.

Sidewalks that are not confined between a street curb and the wall of a building require forms of the type shown in Fig. 42. These are constructed by driving stakes *a* securely into the soil and securing the side pieces *b* to these stakes after these members have been properly leveled and straightened. These forms should project slightly above the level of the soil adjoining the sidewalk. Materials that are to form the concrete should be carefully proportioned and thoroughly mixed while dry, the water then added and the materials again mixed until the mass assumes a uniform color and is sufficiently plastic so that it can be tamped but will not flow. This concrete is then placed on the subbase and tamped by means of a rammer, one type of which is shown in Fig. 43 (*a*), until the surface is approximately smooth and at the level desired. The board or templet *c*, Fig. 42, which has been formed with a running edge and curved to the shape of the crown for the sidewalk, is then drawn back and forth over the concrete to secure the exact lines and surface desired.

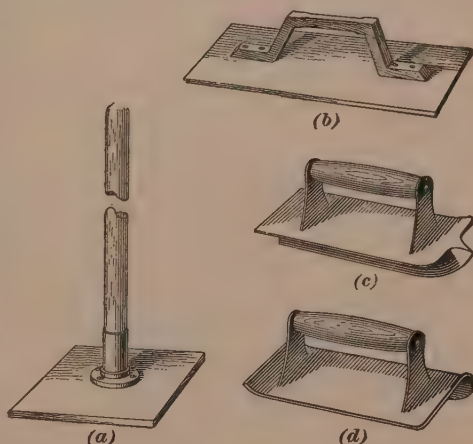


FIG. 43

Joints between the concrete blocks are usually formed by means of a thin wooden or metal cross-form, as shown at *f*, which is located in the position desired before the concrete is deposited. The wooden cross-form may be held in place by means of stakes, or preferably may be secured to the side forms in such a manner that it can be easily removed when required.

When the concrete base of two adjoining blocks has been completed, the cross-form is removed and the joint that has been formed by the removal of this form is filled either with

sand or felt paper or some similar material to preserve the joint during the process of applying the top coat. The location of these joints should be marked on the top edge of the forms so that the joints in the top coating may be located directly over those in the concrete base. Joints in sidewalks are sometimes formed by completing every other block of concrete and, when this concrete has set, removing the cross-forms and installing concrete in the intermediate panels. A walk that is being constructed in this manner is shown in Fig. 44. The panels *a*

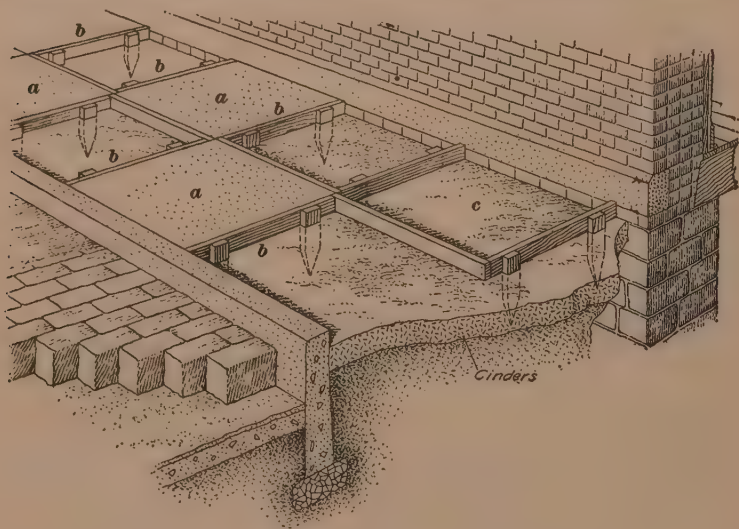


FIG. 44

have been completed and the cross-forms *b* are still in place. Forms are also in position for the concrete to form the panel *c*.

This method of construction permits of access to all sides of each panel, which facilitates finishing both the edges and the surface.

Sidewalks that are likely to be exposed to extreme heat or cold should have some of the joints between the blocks made from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch wide to permit the concrete to expand and contract. These joints are called expansion joints and are usually located about 50 feet apart in the length of the walk. Expansion joints in wide sidewalks of the business districts of

cities are usually provided at the curb and the building line in addition to those mentioned and these joints are filled with asphalt or an elastic cement that will prevent water entering the vault through these places.

66. The top of the sidewalk should be applied as quickly as possible after the base has been finished. If the base has become dry, as it is likely to in hot weather, there is no assurance that the top will bond with the base unless every precaution is taken when placing it. The method usually adopted to obtain this bond is to wash the concrete base thoroughly with water and apply a thin coat of cement mixed with water, then apply the top surface on this while it is still wet.

The top coating is usually tamped, then leveled and smoothed with a templet similar to that used for smoothing the concrete base. The same templet may be used if desired, by adding blocks, as at *e*, Fig. 42, to the running edges to raise the templet to the desired height. This templet is drawn back and forth over the surface; additional surfacing material is deposited as required and the templet is operated until the entire surface of the sidewalk has been brought to the levels of the wooden grounds. When this has been completed, the surface of the sidewalk is treated to produce a smooth or rough surface as desired.

67. Concrete sidewalks are usually finished by means of a wooden trowel as shown in Fig. 43 (*b*), or a coarse brush, as these tools will produce a somewhat rough surface. A sidewalk finished with a metal trowel will be very smooth and become slippery in wet weather and consequently dangerous to pedestrians.

Joints in the top coating should be made directly over those formed in the base so that cracks due to settlements, contraction or expansion will not run across the panels, but will develop at these prepared joints. These joints are finished by means of a tool called a *groover*, shown in (*c*), which also forms a neat border line near the joint.

The edges of the sidewalk adjoining the wooden forms are usually finished with an *edger*, shown in (*d*). This tool forms

a round edge and also a border that is similar to that formed at the joints.

68. Coloring matter, such as lampblack or other mineral pigment, is sometimes mixed with the top coat to secure a desired color; the proportion generally used is from $\frac{1}{2}$ pound to 4 pounds of the dry color to 100 pounds of the dry cement. This is based on the use of mortar that is composed of one part of cement to two parts of sand. The use of greater proportions of color to the cement than noted above is not advisable, as it is likely to prove injurious to the mortar and prevent it from becoming sufficiently hard to be effective.

Sidewalks that are laid in hot weather should be covered with canvas as soon as completed, to shield them from the

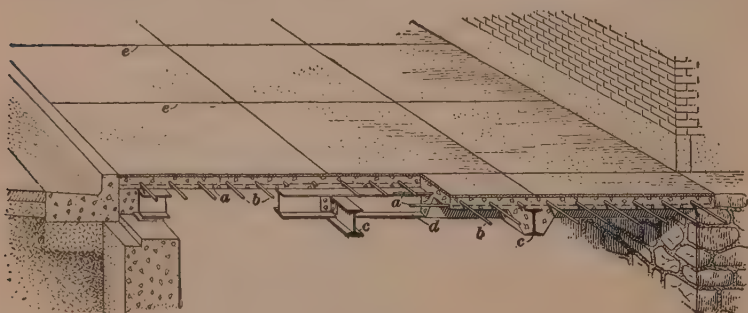


FIG. 45

sun's rays, and thus permit the cement to set slowly. This covering should be removed at intervals and water applied to the sidewalk to keep the concrete damp for a period of two or three days.

69. Reinforced-Concrete Sidewalks.—Concrete sidewalk slabs that are required to span spaces between bearings are reinforced with steel. Rods are sometimes used for this purpose, as indicated in Fig. 45 at *a* and *b*, although heavy expanded-metal lath or other form of steel may be used. The bearings in this illustration consist of the curb, the foundation wall of building and steel beams. The steel beams *c* are placed parallel with the wall of the building and are supported by other steel beams that extend from the curb wall to the building

wall. Part of one of these beams is shown at *d*, and others are located at points *e*. The steel beams are shown encased in concrete, but this is not a necessary part of the construction, as the reinforced-concrete slab extends over the top of the beams and rests directly on them.

The kind of reinforcement selected will depend upon the availability of the material. The thickness of the reinforcement will be determined by the weight of the slab and the live load that it is required to carry, also by the distance between the supports, or bearing points, that the slab is required to span.

Reinforced-concrete girders are sometimes used in this construction instead of the steel beams *c* and *d*.

The construction of the base and the top coating is similar to that of the corresponding parts of concrete sidewalks previously described.

The concrete base in this case is built upon forms that are supported by the beams and are removed after the sidewalk has fully set. The base, however, is not cut into squares nor are expansion joints formed as the steel reinforcement counteracts the contraction and expansion of the concrete. The top coating, however, may be cut into squares if so desired.

Reinforced-concrete sidewalks such as have been described are also built directly upon the soil with suitable beds of cinders beneath them. The reinforcement prevents the sidewalk from cracking, as it counteracts the effect of expansion and it also keeps the sidewalk from deflecting or sagging.

Curbstones and gutters for street roadways are usually installed under city contracts. When the owner of a property, however, erects a vault of the character shown in Fig. 37, the curb is usually formed as a part of the curb wall and the exposed edges of this curb will have to be provided with a metal member as shown at *s*, to protect this edge and withstand the wear due to vehicle traffic.

70. Asphalt Sidewalks.—Asphalt is sometimes used as a surfacing material for sidewalks. It is not suitable, however, for use in localities subject to extreme heat or cold, as the heat softens the asphalt to such an extent that the traffic disfigures

and destroys the surface and the cold causes contraction cracks that permit water to enter into the foundation and thus cause the sidewalk to deteriorate.

The asphalt is prepared by heating in large kettles until it becomes a liquid, after which sand is added and mixed with the asphalt until the desired consistency is obtained. This is then applied to a concrete base similar in character to that described for concrete sidewalks.

The asphalt is tamped and rolled while hot until the desired surface has been secured and is usually about $1\frac{1}{2}$ inches in thickness when finished. After the asphalt is rolled, dry cement is sprinkled over the surface and distributed with a broom.

SIDEWALK LIGHTS

71. Definition.—Sidewalk lights are panels or frames containing pieces of glass that are inserted or built into the pavement over a vault to permit of light entering the vault or adjacent parts of the cellar or basement. These lights are sometimes called *pavement lights* or *vault lights*.

Sidewalk doors, covers of ventilators, and coal-hole covers are often provided with these glass panels and thus serve as sidewalk lights.

72. Parts.—The parts of the sidewalk lights are the glass, either in the form of small sheets, or of lenses, and the frame or construction in which the glass is set. This frame or construction may be of metal or of reinforced concrete, and is formed with subdivisions that are of a suitable size to hold the glass.

73. Building Laws.—Building laws of cities usually define the character of sidewalk lights and the details of their construction. The following specifications cover the essential features that are considered necessary to make them safe for the use of pedestrians:

The construction shall be of a character that will be sufficiently strong to support the traffic that usually comes on the sidewalk.

The plain surfaces of glass and iron shall be of a limited area, as these materials become very slippery when wet and are consequently dangerous to pedestrians.

The top surface of metal, when so used, also of concrete when the frame is formed of this material, shall be finished rough or treated with a material of the character of carborundum to afford a secure footing.

74. Types and Uses.—There are two general types of sidewalk lights. One type has plain glass panels or plain flat



FIG. 46

lenses,* as shown in Fig. 46, that permit the rays of light to pass through them without being deflected. These will light only the portion of the vault directly below the sidewalk light and they are generally used to illuminate vaults that are enclosed on all sides by walls.

The other type has lenses that on their under sides have sloping extensions, called *pendants* or *prisms*, as shown in Fig. 47, which cause the rays of light to be deflected as they pass through them. Such lenses are used in sidewalks over vaults that are open on the side toward the basement of the building and permit of illuminating both the vault and portions of the basement adjoining.

75. Lenses. — All lenses are formed of glass that is made especially for the purpose of sidewalk lights. It is the aim of the manufacturers to produce a glass that will retain its brilliance, toughness, and resilience, as these qualities are necessary to good service.

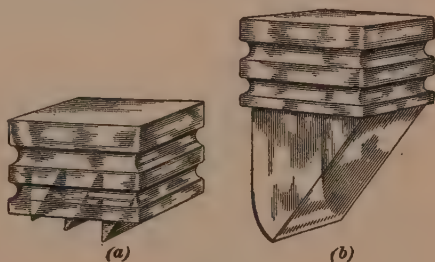


FIG. 47

*Flat lens, as here used, is a trade term. Ordinarily, a lens must have at least one convex or concave face.

Lenses are made both square and round in form, as shown in Figs. 46 and 47. The edges of the lenses are made in many shapes, the one shown in (c) of Fig. 46 being so designed that

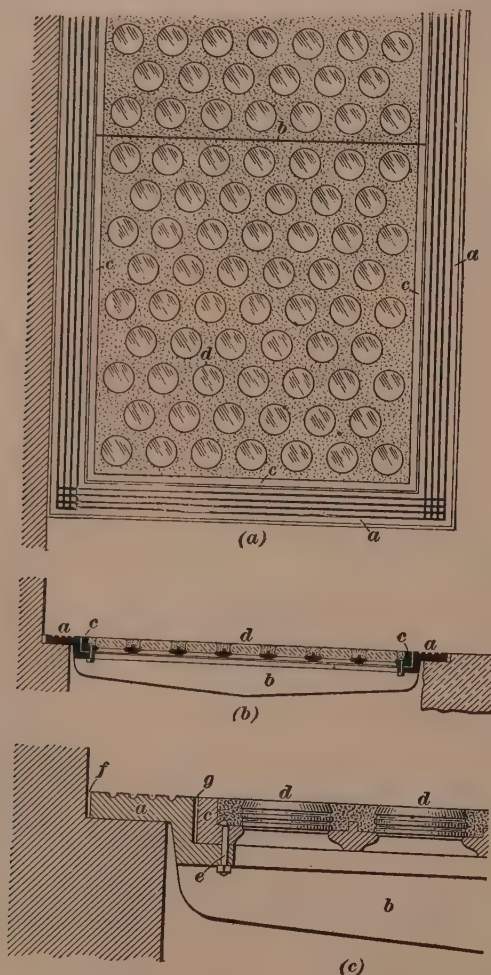


FIG. 48

it may be removed if it becomes broken and a new one put in its place without causing any damage to the concrete in which it is set. In this case the metal wire *a, a* is firmly held by the

cement and forms a screw thread by means of which the lens may be screwed into place.

76. Construction.—Metal frames for sidewalk lights may be made of cast iron, steel bars, or sheet steel reinforced by means of steel bars of standard shapes. In Fig. 48 is shown a cast-iron frame of the type most generally used. In this illustration the plan is shown in (a), a section through the frame in (b), and a detail of the frame in (c). In all of these figures, the outside frame is indicated at *a*, the cross-ribs at *b*, the inner frames which form the panels at *c*, and the lenses at *d*. In (c) it will be noted that the outside frame has a shelf on which the inside frame rests and that these frames are fastened together by means of a bolt as shown at *e*. This connection is made before the concrete is filled around the lenses. The joint between the outside frame and the wall at *f*, and the joint between the two frames as shown at *g*, also the joint between the panels as shown at *b* in (a), should all be filled with an elastic cement.

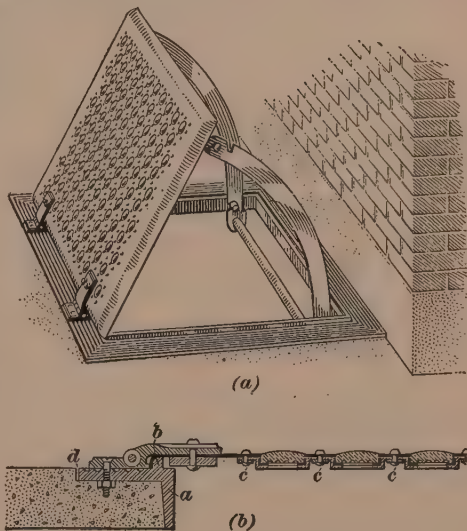


FIG. 49

77. In Fig. 49 (a) is shown a sidewalk door intended to admit both light and air into a vault. Lenses similar to those used in the sidewalk are placed in the door, and the door is equipped with hinges and an operating device that permits of the door being opened and closed from within the vault.

The frame of the door, shown at *a* in (b), is of cast iron, and on its top surface are grooves and an upward-projecting

lip *b*, over which the edge of the door laps. The door is usually formed of No. 12 gauge sheet steel, and holes are cut in this

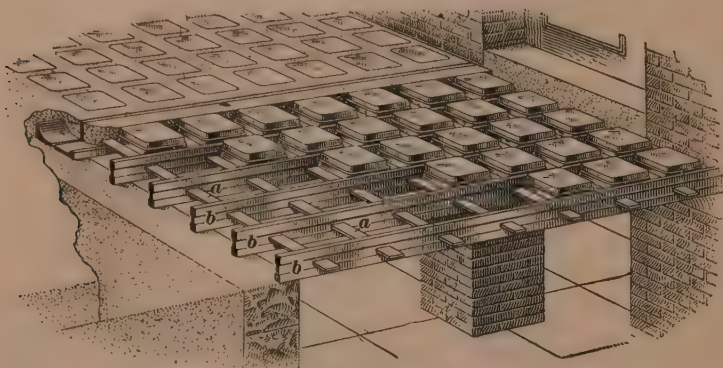


FIG. 50

plate where the lenses are to be located. Separate pieces of sheet steel *c* into which the lenses fit are attached to the under side of the door, and in them the lenses are placed and secured by means of a cement made of sulphur and tar. The joint *d* between the door frame and the sidewalk should be cemented in the same manner as described for other sidewalk lights.

78. Fig. 50 shows a steel frame built up of standard sections *a* and *b*. Spaces are provided for the individual lenses and cement mortar is poured between the lenses and over the steel supporting frame. In Fig. 51 is shown a sheet-metal

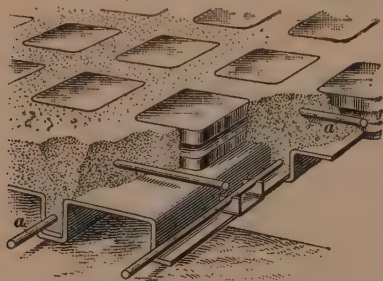


FIG. 51

frame that serves as a support, or form, upon which to cast the concrete. The lenses are put in place, the reinforcing rods *a* are placed as shown, and concrete is poured around the lenses and around the reinforcing rods.

In Fig. 52 is shown a construction formed of reinforced concrete which supports the glass lenses. This construction is built upon wooden forms on which the lenses and the

reinforcement are placed. The concrete is then poured and fills the spaces around the lenses and the bars, forming a solid slab which is self-supporting after the cement has set. When the slab has become strong enough to support the required loads the forms may be removed.

79. There are various other forms of sidewalk lights, each having its own system of construction. Manufacturers of these lights usually suggest how their products should be assembled and installed.

Sidewalk lights for flagstone sidewalks are set after the stone slabs are put in place. Suitable openings in these walks must be provided and the top face of the stone adjoining the openings must be cut to form a recess so that the frame may be set flush with the surface of the stone.

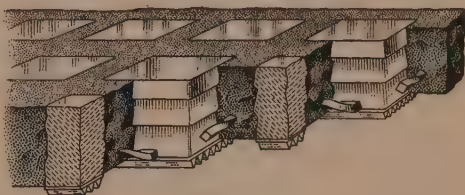


FIG. 52

The metal parts and the lenses of sidewalk lights that are to be formed in concrete sidewalks are usually assembled before the sidewalk is laid, and the concrete which encloses the lenses is installed at the same time that the sidewalk is formed.

Carborundum grit is sometimes mixed with the top coat of the concrete which is used to fill around the lenses, to form a surface that will afford a good footing for pedestrians. If this material is used, the concrete should be allowed to become hard before it is subjected to foot traffic, otherwise the grit may be torn away from the concrete.

RETAINING WALLS

DESCRIPTION AND PRINCIPLES

80. Definition.—A retaining wall is one that retains in place a filled-in backing of soil or rock, or holds in place a bank of gravel, sand, or soil that is not compact enough to retain its form when a vertical cut is made in the bank.

81. Types of Retaining Walls.—There are two types of retaining walls, each involving a different principle of design and requiring a different form of construction. One of

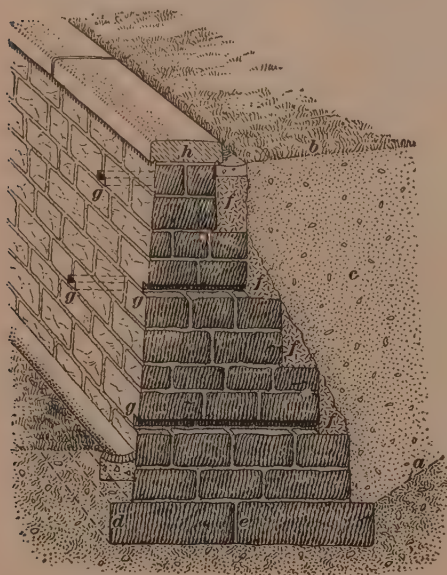


FIG. 53

these types depends upon the weight of the material of which the wall is built to resist successfully the lateral pressure from the soil and is formed of masonry or concrete to obtain this weight. Such walls are called *gravity walls*. One form of gravity wall constructed of stone masonry is shown in Fig. 53, while another form, made of concrete, is shown in Fig. 54.

The other type of retaining wall depends upon the form or shape of the wall, rather than upon its weight, to resist the pressure from the soil, and is designed to act as a lever, or what is known as a *cantilever beam*. From this fact it is some-

times called a *cantilever retaining wall*. This form of wall is constructed of reinforced concrete and is also called a **T** type of retaining wall on account of the inverted **T** shape that is formed by the wall and the base on which the wall rests. A retaining wall of this type is shown in Fig. 55.

82. Design.—The design of retaining walls is difficult and filled with uncertainties. Moreover, retaining walls, although carefully and elaborately designed, often fail. For this reason rules are used which are not based entirely upon mathematical calculations, but which depend largely upon experience.

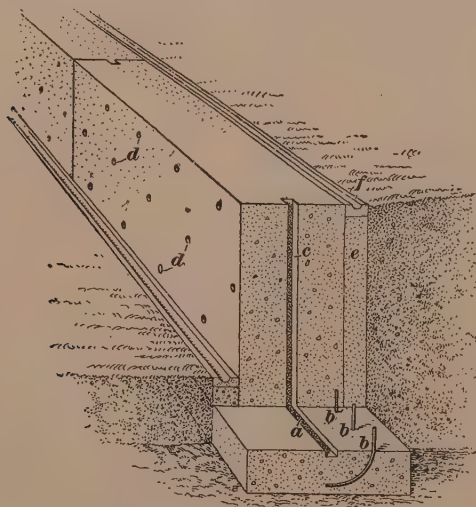


FIG. 54

Probably the best series of rules for designing gravity retaining walls that are to have the exposed faces vertical and to be of uniform thickness throughout their heights is that presented by John C. Trautwine in his well-known Civil Engineer's Pocket Book. These rules with slight modifications provide the following proportions:

The ratio of the thickness of a retaining wall to its entire height should be .35 for a wall constructed of cut stone or of first-class rubble of large sized stones laid in cement mortar; .4 for a wall constructed of good common rubble laid in cement

mortar, good hard-burned brick laid in cement mortar, or a wall of plain concrete; and .5 for a wall constructed of good dry rubble.

For example, a retaining wall built of good hard-burned brick laid in cement mortar should have a thickness equal to .4 of its total height.

It is assumed that the wall has a foundation of masonry sufficiently large to secure a proper distribution of the load on

the soil, also that the soil filling back of the wall is deposited loosely and leveled to line with the top of the wall. If the filling is tamped and thus made compact, the thickness of the wall may be slightly reduced. This reduction, however, is not usually made.

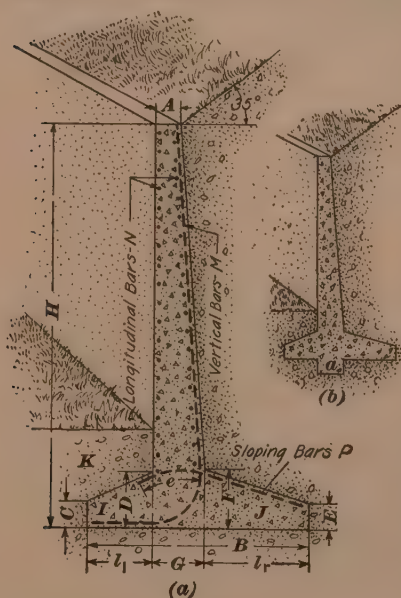


FIG. 55

83. In Fig. 56 are shown diagrammatically five designs that are frequently used for retaining walls. All of these designs require the same amount of material for the wall, the reduction in thickness in

some parts being offset by an increase in thickness of other parts. No footings are shown in these designs, as they do not enter into the designing of the walls, but relate to the bearing values of the soil.

The diagram in (a) represents a retaining wall with vertical faces and a uniform thickness that is equal to .4 of its height. This diagram is used in designing the remaining four forms of walls and is modified as described.

The diagram in (b) represents a retaining wall with a vertical face and a sloping back. To design this wall, draw a

rectangle equal to $a b d c$ of diagram (a); locate the point e midway between b and d and locate the point f on the line $a b$ at such a distance from a as is desired for the thickness of the top of the wall and draw the line $f e$ and extend it to g , then extend the base line $c d$ to g and the section $a c g f$ will be that of a wall having the same sectional area as that in (a).

In (c) a wall with a sloping face and a vertical back is shown. For walls of this form the slope, or *batter*, is usually from 1 inch to 2 inches for each foot in height of the wall and is represented by the line $a e$, the total projection from the vertical line being represented by $c e$. For example, in a wall that is 12 feet high and has a face formed with a slope of 1 inch to the foot of height, the distance between c and e would

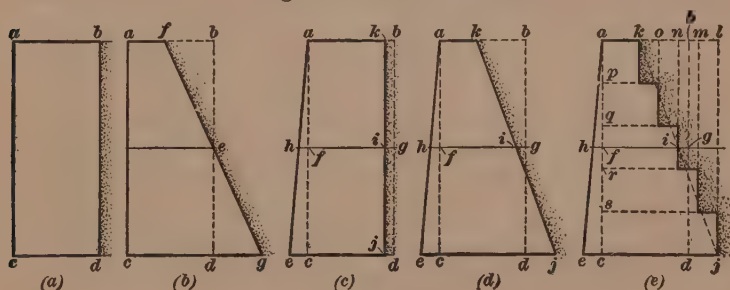


FIG. 56

be 12 inches. After the rectangle $a b d c$ has been drawn and the slope of the face of the wall determined, locate f midway between a and c , also locate g midway between b and d and draw the line connecting these two points. Extend this line to h and lay off $h i$ equal to $f g$. Draw the line $j k$ through i and the section $a e j k$ will have the same area as that in (a) and (b).

In (d) the diagram represents a wall with a sloping back and also a sloping face. In designing this form of wall, the sloping face and the point i are obtained in the same manner as previously described for similar parts in (c). The thickness of the wall at the top is the same as shown in (b) and is represented in diagram (d) by $a k$. From k draw the line $k i$ and extend this line to j , also extend the line $e d$ to j , and the diagram $a e j k$ will have the same area as that in (a).

The wall shown in the diagram (*e*) is of the same size as the one shown in (*d*) and is similar in shape, with the exception that the back of the wall has offsets, instead of a slope. To determine the form of these offsets, on a diagram similar to that in (*d*), draw a vertical line from *j* to *l*, as in (*e*), and divide the distance *l k* into an even number of equal parts, four parts being used in this illustration and shown by *l m*, *m n*, *n o*, and *o k*. Divide the height of the wall *a c* into equal parts, one more in number than the divisions of *l k*, as shown by *a p*, *p q*, *q r*, *r s*, and *s c*. Complete the diagram by drawing lines from the vertical and horizontal subdivisions to form the offsets as shown.

84. As a large majority of failures in retaining walls are due to defects in the foundations, it is of the greatest importance that this part of the structure be properly designed. The area of the footing should be determined primarily with reference to the bearing value of the soil. In determining the size of the footing, however, not only the weight of the wall must be considered, but also the pressure of the soil back of the wall.

In estimating the amount of pressure against the back of the wall it is customary to compute it as the weight of the soil that lies between the finished grade line and the natural slope of the soil, and to design the wall and footing to resist this pressure.

The natural slope may be defined as the line or plane along which the embankment of soil tends to slide. In Fig. 53 this is shown at *a*, the finished grade line at *b*, and the mass of soil which is producing the pressure at *c*.

The angle of the slope depends upon the character of the soil, the angle being less for sand and gravel than for more solid and compact soils.

The slope of the line *a* is 35 degrees above the horizontal, this being the angle usually assumed by engineers when estimating the pressure of the soil.

As the pressure of the soil against the wall tends to overturn the wall, the pressure of the wall on the soil upon which it rests is greater at *d* than elsewhere under the footing. On account of this variation in pressure, a low bearing value of

the soil should be taken when designing the spread of the footings.

The weight of a wall of the gravity type is usually sufficient to prevent the wall from slipping on the soil. Like all other walls, however, the foundations should be carried below the grade level to such depth that they will not be affected by frost.

85. In the design of the wall shown in Fig. 55, the foundation *B* is spread out to secure a good bearing on the soil and prevent the wall from settling.

The projection of the footing in front of the wall, shown at *I* in (*a*), is called the **toe**, and the one at the rear of the wall, as shown at *J*, is called the **heel**, these projections being designed so as to prevent the wall from being overturned by the pressure of the soil back of the wall.

The principles involved in this design are that the pressure against the wall tends to turn the wall around the toe. The weight of the soil which rests on the heel together with the weight of the wall overcome the overturning tendency and hold the wall in place. Steel reinforcement is embedded in the wall and in the footing to supply the necessary strength so that the wall itself will not break.

In this figure, the steel bars *M*, *N*, and *P* are intended to prevent the wall from breaking. Those shown at *M* carry the tension due to the bending of the wall proper and are extended into the toe of the footing. The bars *N* are run longitudinally in the wall to prevent the concrete from shrinking and producing cracks. The bars *P* reinforce the heel of the footing and bond this heel with the base of the wall proper.

The weight of the wall and the soil which rests on the heel of the footing are usually sufficient to keep the wall from slipping on its footing. It is desirable, however, to extend the footing below the lower grade level sufficiently to permit the soil at *K* to form an additional resistance against this slipping. If the footing cannot be carried to this depth an extension may be formed on the bottom of the footing, as shown at *a* in (*b*). All walls exposed to freezing weather should have the footing carried to a point below the frost line.

TABLE I
DIMENSIONS AND REINFORCEMENT FOR T-TYPE RETAINING WALLS
For Meaning of Reference Letters, See Fig. 55

Item	Upright Beam										Left Cantilever			
	Total Height <i>H</i> Feet	Length of Base <i>B</i> Feet	Length of Right Cantilever <i>l_r</i> Inches	Length of Left Cantilever <i>l_l</i> Inches	Reinforcement						For Plain Round Bars <i>D</i> Inches	For Square Deformed Bars <i>D</i> Inches		
					Dimensions of Slab		Plain Round Bars <i>M</i>	Deformed Square Bars <i>M</i>	Plain Round Horizontal Bars <i>N</i>					
					Thickness at Top <i>A</i> Inches	Thickness at Bottom <i>C</i> Inches			Size Inch	Spacing Inches			Size Inch	Spacing Inches
1	8	4.00	20	18	6	9½	4½	4½	3	4½	12	6	6	9
2	12	6.50	39	24	8	15½	4½	4½	3	5	9	8	8	13½
3	16	8.75	50	31	10	23½	5½	5½	3	5½	9	10	10	18
4	20	11.00	62	39	12	31½	4	4	3	5	8	12	12	23½
Item	Total Height <i>H</i> Feet	Right Cantilever										Unit Pressure on the Soil		
		For Plain Round Bars <i>P</i>					For Deformed Square Bars <i>P</i>					Maximum Pounds per Square Foot	Minimum Pounds per Square Foot	
		Dimensions of Slab		Length of Embed- ment <i>e</i> Inches	Spacing Inches	Size of Round Bars Inch	Dimensions of Slab		Size of Square Bars Inch	Spacing Inches	Length of Embed- ment <i>e</i> Inches			
		Thickness at End <i>E</i> Inches	Maximum Thickness <i>F</i> Inches				Thickness at End <i>E</i> Inches	Maximum Thickness <i>F</i> Inches						
1	8	6	13½	11	5	7/16	6	8½	3/8	4½	12	2,450	0	
2	12	10	18½	20	4½	5/8	8	14	3/8	6	21	3,700	0	
3	16	12	28½	29	5	7/8	10	19½	3/8	6	24	5,000	0	
4	20	14	35½	36	4½	1	12	29½	3/8	5½	29	6,100	300	

NOTE.—In the retaining-wall design the following working stresses and conditions are assumed:

Compression in concrete, 500 pounds per square inch. Tension in steel, 16,000 pounds per square inch. Bond of plain bars to concrete, 80 pounds per square inch. Bond of deformed bars to concrete, 120 pounds per square inch. Shear involving diagonal tension, 40 pounds per square inch. Slope of earth above wall, 35°; weight of earth, 100 pounds per cubic foot.

Courtesy of the Atlas Portland Cement Company, New York.

86. In Table I dimensions and reinforcement for **T**-type retaining walls are given, which will be found useful when designing retaining walls of a simple character. When the problem is complex, however, the designing of the wall should be referred to an engineer who is thoroughly familiar with such work, as it is not customary for architects to design any but the most simple gravity walls. It will be noted that in Table I sizes and spacing for either plain round, or square deformed bars are given, so that either may be used.

MATERIALS

87. The materials that are best adapted to the construction of retaining walls of the gravity type are stone and concrete, as they are heavy, and in this type it is the weight of the material that enables the wall to resist the lateral pressure of the adjoining soil. If brick is used for such walls the bricks should be hard burned so that they will not absorb moisture and thus cause the wall to deteriorate when exposed to the frost. As previously stated, concrete reinforced with steel is the only material that is used for the **T**-type retaining walls.

CONSTRUCTION

88. Excavation.—Excavations for retaining walls should be of ample size and proper shape for the work contemplated. Soil that is likely to break away and fall into the excavation should be supported during the construction of the wall in a manner similar to that described under the head of Bracing the Soil in connection with the subject of Area Walls.

89. Construction.—Retaining walls formed of stone or brick should be constructed in the same general manner as described under the head of Area Walls. Only cement mortar should be used for this construction and all joints and crevices should be thoroughly filled with the mortar and carefully pointed. If the wall is to be of concrete, however, wooden forms will be required and the construction of the forms and the wall will be similar to those previously described.

The wall shown in Fig. 53 is of the gravity type, with offsets formed in the back of the wall. Stone for such a wall should be large and partially squared, so that the joints and crevices may be small and easily filled with the mortar. The joints of such walls should be carefully pointed. Stones selected for footings should, if possible, be larger than those used in the wall and should break joints with the wall stone, as shown at *e*. The filling *f* on the offsets at the back of the wall should be of cinders or gravel, so that the water will drain to the offsets and through the chases *g* to the face of the wall. Openings of this character are called *weep holes*. Pipes of glazed tile are sometimes used for weep holes; also iron pipes, but the rust from the iron pipes will disfigure the wall.

The top of such a retaining wall should be protected by means of a coping, as shown at *h*.

90. A gravity-type, plain-concrete wall with a straight face and back is shown in Fig. 54. The footing course of this form of wall is usually cast independent of the wall, as this method facilitates the construction of the wall forms. It is necessary, however, to construct the footing in such a manner that it will be anchored and bonded to the wall after the wall is cast. To obtain this bond a groove, as shown at *a*, is usually formed in the top of the footing which later becomes filled with the concrete of the wall and thus a tongue-and-groove joint is formed between the wall and footing. This form of joint prevents any possibility of the wall sliding on the footing. It is also desirable to provide anchors between the footing and the wall, as shown at *b*, to resist the forces which tend to cause the wall to topple over. These anchors may be of $\frac{3}{4}$ -inch steel bars, spaced about 2 feet on centers and formed as shown.

Walls of this character are made in sections one at a time by placing a partition in the forms at the point where it is desired that the joint shall occur and then pouring the concrete into the forms so as to cast the first section. This partition should be designed to form a groove in the end of this section as shown at *c*. When the concrete of this section has become set, this partition is removed and located at the point where

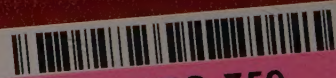
the next joint is to be formed, and this operation is continued until the various sections forming the wall have been completed. After the partition has been removed from a section that has been just cast, sand should be sprinkled over the end of this section, or a piece of tarred paper inserted, to prevent the new concrete from bonding with that which has been previously cast.

The openings shown at *d* are weep holes through which water may drain from the cinder filling *e* back of the wall. Where there is likely to be surface water from an adjoining bank of soil, a gutter as shown at *f* is often laid to carry away this water to a point beyond the end of the wall.

The **T** type of retaining wall shown in Fig. 55 requires wooden forms so constructed that the footing and the wall may be cast at the same time. The reinforcing bars should be located in their proper positions and so secured in place that they will not be misplaced when the concrete is deposited. Gravel used for the concrete of these walls should be small in size and the mixture thoroughly puddled as it is placed, so that the concrete will entirely enclose the steel and form a smooth even surface on the face of the wall.

Weep holes of the same character as previously described are usually formed in these walls.

91. Back filling of soil adjoining all walls should be tamped as it is deposited, so that the filling will be as compact as the natural soil adjoining, and the surface of the filled parts should be made with a slope to drain water away from the wall wherever this is possible.



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